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QUEENSLAND

COTTON RESEARCH STATION, BILOELA.

PROGRESS REPORT FOR THE SEASON 1940-41.

BY

W. G. WELLS.

Introduction.

The progress report on the investigations conducted at the Cotton Research Station has been prepared from the reports submitted by Mr. S. Marriott, Assistant Research Officer, who was responsible for the operations connected with cotton breeding and genetics, Mr. W. A. R. Cowdry, Instructor in Cotton Culture, who reported on the experiments carried out under dry farming conditions, and Mr. F. Chippendale, Instructor in Cotton Irrigation, who conducted the irrigation experiments. The appended entomological notes have been compiled from reports submitted by officers of the Entomological Section, Division of Plant Industry (Research). All statistical analyses were supplied by Messrs. H. M. Finucan and P. McGovern, Assistant Research Officers (Biometry), Department of Agriculture and Stock, Brisbane.

A feature of the season's operations has been the inauguration of a series of investigations relating to growing cotton with supplementary irrigation facilities. The erratic rainfall experienced in recent seasons has focused considerable attention on the desirability of growing cotton with the assistance of supplementary irrigation wherever watering facilities can be provided economically. The results obtained by a few farmers who, with the assistance of the Queensland Cotton Board, installed individual pumping plants on streams during the two previous seasons, indicated that yields can be appreciably increased in dry seasons by the application of an early pre-planting watering and one or two subsequent waterings at critical stages in the development of the cotton crop. The Queensland Government, in order to test the merits of this form of cotton-growing on an extensive basis, during the season under review financed some fifty farmers who had suitable tractors to enable them to purchase individual irrigation equipment. The plants consist of 4-inch centrifugal pumps and 4-inch main and spray lines capable of applying around 12,000 gallons of water an hour. As part of the scheme, irrigation facilities for a 10-acre area were developed at the Research Station, and an officer with experience in spray irrigation was appointed to conduct the investigations carried out at that centre.

Mr. H. M. Goulter, who was appointed to assist Mr. Marriott,

obtained leave of absence early in the season to join the R.A.A.F. for overseas service, which necessitated considerably reducing the plant-breeding programme originally designed for the season. At the end of the season, Mr. Chippendale obtained leave of absence to join the A.I.F.

Climate.

The climatic conditions experienced during the season, while definitely not conducive to high yields, were more favourable than those of the previous season and all experiments produced sufficient cotton to make the results obtained of some economic value.

The rainfall during the winter, spring and early summer was well below the mean for previous years and it was not until the end of November that the rain-grown experiments could be planted. The rainfall for December, January and February was also below average, but was just sufficient to maintain a slow development of the plants which, with the assistance of very good rains in March, produced a moderately good crop on the best of the experiments. Unfortunately a jassid attack destroyed some of the top crop, otherwise fairly satisfactory yields considering the season would have been obtained in many of the experiments.

The seasonal summary of rainfall in comparison with the means of previous seasons is included to indicate the conditions under which the crop was grown.

Season.	*June–Sept., inclusive.*	*Oct.–Nov., inclusive.*	*Dec.–Feb., inclusive.*	*Mar., April, May.*	*Seasonal Total.*	*No. of Wet Days.* 1940–41.
1940–41	1·73 ins.	4·38 ins.	7·95 ins.	9·05 ins.	23·11 ins.	86
Previous Mean ...	4·93 ins.	4·62 ins.	12·85 ins.	6·20 ins.	28·60 ins.	76

Temperatures for the season were generally favourable for cotton, the mean maxima during January and February being mostly below the previous means for these months and slightly above the mean in the maturation period of the crop. The minima temperatures throughout the season were mostly above the previous mean. The first killing frost occurred on June 27th, when 25·5° F. was experienced.

An interesting feature of the season was the extraordinary amount of cloudiness prevalent during most of January, the first half of February and the latter half of March.

Genetics and Breeding.

The programme for the production of a jassid-resistant variety for the Callide Valley received some set-backs in the 1940–41 season.

A serious outbreak of *Austracris guttulosa* (spur-throated locust),

despite all attempts to destroy it, destroyed a plot of 100 strains of Miller selections that were being tested for jassid-resistance in an outlying plot in the " jassid section " of the district. Reserves of seed are available, but the delay is unfortunate, as one strain in tests on the Research Station showed definite promise for both high yield and jassid-resistance under conditions of moderate jassid infestation.

Observations indicated that in the Miller variety jassid-resistance would appear to be correlated with a number of factors in addition to hairiness, such as, slight lateness of development and maturation of crop, smaller bolls, prolificness, leafiness, and a coarser leaf texture.

The hybrids yielded interesting data from which it was evident that Miller back-crosses were proving superior to the F_3's and F_4's of Miller$\times$U.4 hybrids in boll and lint characters, while jassid-resistance was mostly satisfactory under the conditions prevailing for the season. The backcrossing programme is being continued.

Preliminary tests of the possibility of propagating cuttings obtained from the main stalk and older vegetative branches having yielded satisfactory results, the pollinating programme has been revised somewhat and vegetative reproduction has been introduced. This should assist in the selection and maintenance of outstanding individuals from segregating material, which is a most important consideration under the usual conditions experienced at the Research Station, as many essential characters are frequently not apparent until all chances are passed of obtaining self-pollinated seed for the season.

Other varieties have been inspected, and Cliett yielded apparently jassid-resistant plants which will be tested in the coming season. This is an attractive variety which yields well when free of jassid attacks. It is very susceptible to jassid injury, however, and has therefore increasingly lost favour with the growers in recent seasons.

Strain Tests.—The development of more recently improved strains in several of the varieties which have possibilities on the alluvial soils similar to those of the Research Station, has reached the point where careful testing under comparable conditions is required to determine their respective merits. A strain test was therefore carried out at the Research Station which embraced eight strains of Oklahoma Triumph—a full $\frac{15}{16}$ inch staple very early maturing variety, the name of which has been shortened to Triumph in Queensland—a $\frac{15}{16}$ inch staple strain of Half and Half which has a very high lint percentage and yields well, a strain of the Miller variety III.26–0 which Mr. Marriott has developed, which gives a staple of 1 inch and gives definite promise of being fairly jassid-resistant, two strains of the New Boykin variety—a $\frac{15}{16}$ inch staple, medium boll type with considerable degree of drought resistance—

two strains of Indio Acala, a $1\frac{1}{8}$ inch staple, big boll type and, as a control, the bulk strain of the Miller variety which is the most extensively grown cotton in the Callide Valley.

The strains were planted on cultivation newly brought in out of virgin grassland, and, under the dry conditions, experienced a definite suppression of the height of the plants as well as other characters such as size of boll, leaf, etc. There appeared to be a differential varietal response to the conditions, however, in some characters such as size of boll, where boll weights suggested that the bolls of the early-fruiting varieties obtained greater benefit from the good March rains that did those of the later-maturing Miller. The bolls of this variety were proportionately more reduced in size than were those of any of the medium boll type, early-fruiting varieties.

Flower counts made during the first nine weeks of the flowering season indicated that each of the eight strains of the Triumph variety produced more flowers than did any other variety.

The yields obtained indicated that Miller III.26–0, although definitely slower flowering than all of the Triumph strains, yielded as well as the best of them and significantly outyielded all other strains except the parent Miller which, however, tended to produce substantially less cotton than the offspring. Miller III.26–0 produced the highest actual yield—669 lb. seed cotton per acre—while one of the Indio Acala strains produced the lowest yield with 462 lb. F (ratio of mean squares) for varieties was highly significant, although there was no significant difference between the leading eight strains.

Experiments.

Although much work remains to be done to solve some of the problems which have been encountered in growing cotton at the Research Station and in the adjacent district, the progress that has been accomplished in elucidating some of the causes of the low yields that have been realized in some of the past seasons warrants an increased amount of attention being given in the experimental programme to varietal testing. Accordingly a comprehensive series of varietal tests on various soil types and ages of cultivation have been conducted at the Research Station this past season, and the results obtained are reported under the following experiments :—

Main Varietal Test (F.17–19).—A 12×6 randomized block experiment embracing a range of the older varieties suitable for the soils of the Research Station and some of the more promising of the more recently introduced varieties was conducted on first year cultivation out of virgin grassland.

Flower counts made during the first nine weeks of the flowering period yielded results in keeping with those anticipated for each class of varieties, the recognized early flowering types substantially producing the most flowers. While there was a significant tendency for the varieties producing the most flowers to yield the greatest amount of cotton, there was no positive correlation between high amount of flowering in the first three weeks of flowering and high total yields. The analysis of variance for regression indicated that the amount of flowering in the second three weeks had the greatest effect on final yield, the varieties flowering the most in that period producing the best yields. There was a definite tendency, however, for the varieties which produced the highest total number of flowers in the first six weeks to show the first temporary wilting. The yields produced indicated the effect of the seasonal conditions, the two leading varieties producing respectively 603 and 601 lb. seed cotton per acre, while the lowest variety yielded only 439 lb. with the bulk of the varieties ranging from 500 to 571 lb.

Varietal Test for Mechanical Harvesting Trial.—The Queensland Cotton Board, in order to ascertain the possibilities of mechanical harvesting of cotton under Queensland conditions, imported from the United States of America in the previous season a Rust Mechanical Cotton Picker. In the trials conducted that season in the Callide Valley results were obtained which tended to indicate that the type of plant structure would be a very important factor affecting the efficient operation of the machine. A varietal trial consisting of seven of the varieties most suitable for the soils of the Research Station was therefore planted this season on four-year-old cultivation out of virgin grassland (C.12–17), and on first cultivation following three years' establishment of Rhodes grass on an old cotton cultivation (I.5–10). The row spacing was $3\frac{1}{2}$ ft. in each experiment, with 1 ft. single-plant spacing.

The experiment on C.12–17 made very even growth until the March rains, following on which a bushy, very leafy type of plant developed which was obviously unsuitable for machine harvesting. The trial was therefore hand-picked as a 7×4 randomized block experiment and the results obtained confirmed those given by the same varieties in the F.17–19 experiment, the relative order of merit being similar, with the exception of an interchange of the second and third leading varieties. The two leading varieties in the C.12–17 trial, which were of the quick maturing type, produced respectively 68 and 65 lb. more seed cotton per acre than they did on the first-year cultivation. Results obtained in previous experiments have likewise indicated that the yields of quick maturing varieties grown on cultivations in the first season

following grassland may be reduced somewhat in dry seasons, due to a deficiency of nitrates. Conversely, the two most vigorous growing and drought-resistant varieties produced respectively 42 and 91 lb. more seed cotton per acre on the first-year cultivation than on the fourth-year cultivation. Triumph, the highest yielding variety, produced at the rate of 671 lb. seed cotton per acre.

The companionate test, I (5–10), which was planted on first-year cultivation following three years of Rhodes grass on old cultivation, produced in all varieties plants of a more suitable type for machine harvesting. All were of definitely smaller structure, however, than would usually occur under more normal mid-seasonal rainfall, so the results obtained with the mechanical harvester may not be thoroughly indicative of the true merits of the varieties for this form of harvesting.

At harvesting time 2 rows of each plot of each variety were picked by hand and a similar number with the machine harvester. The yields obtained by hand-picking once again indicated the superiority of the quicker maturing varieties for such climatic conditions as were experienced, but the order of merit for the other varieties was changed somewhat from that established in C.12–17. All varieties yielded substantially better in this experiment than on either the first or fourth year of cultivation out of virgin grassland, the gains in the cultivation following Rhodes grass compared with the fourth year of cultivation (C.12–17) ranging from 209 lb. seed cotton per acre for the quickest maturing variety, to 49 and 83 lb. seed cotton for the two slowest maturing varieties. Table I presents the yields obtained in the

TABLE I.

Variety.	*Machine Yield.*	*1% Significant Differences.*	*Hand Picked.*	*1% Significant Differences.*	*Efficiency % of Machine.*	*1% Significant Differences.*	*Expected Machine Yield.*	*Varietal Effect (excess of actual over expected).*	*Significant Differences.*
Oklahoma Triumph ...	600	OT > B	880	OT > NMA	68·2	IA > B	542	+ 58	
Miller ...	536	OT > IA OT > HH	697	OT > IA OT > Q	76·9	IA > HH	474	+ 62	OT > HH M > HH
New Mexico Acala ...	534	OT > Q	661	HH > IA	80·8	NMA > B NMA > HH	460	+ 74	NMA > HH
Boykin ...	460	M > HH M > Q	766	HH > Q B > IA	60·1	M > HH	500	− 40	IA > HH NMA > Q
Indio Acala...	437	NMA > HH	523	B > Q	83·7		408	+ 29	
Half and Half	393	NMA > Q	781	M > Q	50·3		505	−112	
Q'ualla ...	315		466	NMA > Q	67·7		386	− 71	

experiment from both forms of harvesting, as well as the indicated efficiency of the machine for harvesting these varieties under the conditions in which they were grown.

In view of the differences obtained between the percentage of the crop picked by the machine in each variety, the data were subjected to an analysis of co-variance which indicated that after eliminating varietal effects a large hand pick was accompanied by a large machine picked yield, but that proportionately the machine performed better in the plots where a low hand picked yield was obtained. In this respect it is interesting to note, however, that a second run over two rows each of Half and Half and Triumph produced further yields which amounted to gains of 20·2 and 20·3 per cent. respectively of the previous harvesting by the machine.

Samples of seed cotton from each form of picking of each variety were forwarded to the graders for a report on their relative merits. The cotton was unfortunately exposed to a fortnight of intermittent showery weather just before the harvesting operations. The grader reported that the colour was thus so dull as to necessitate placing all treatments into the Strict Low Middling grade. Generally speaking, it was found that the hand-picked cotton had larger pieces of leaf, which were dry and loosely contained in the cotton, as compared with the machine-picked cotton, which contained leaf that was broken into smaller pieces, and in some instances a fair percentage of green leaf was present which was closely impregnated into the fibres. The hand-picked cotton contained more diseased and immature locks than did the cotton picked by the machine, which apparently exercised some degree of selectivity in this respect. The elimination of such locks should lessen the amount of light spots contained in the resultant lint cotton.

Altogether the results of the trial were encouraging as the cotton through being exposed to such adverse weather undoubtedly was not in such good condition for machine harvesting as would be less weathered cotton, which would not be in such a matted condition in the bolls.

Varietal Tests on Different Ages of Cultivation.—The investigation under this heading, which was described in last season's Report, was conducted this season on the same sites as in the previous season, thus adding one year to the age of each cultivation.

In the early stages of plant growth no differences between the cultivation treatments were discernible, except in the newest cultivation out of virgin grassland on which the plants flowered the best, as was the case all season. The usual count of fruiting nodes, squares, bolls and shedding was made early in February on the Miller variety in each age of

cultivation. No significant differences were obtained, except in the number of fruiting nodes. The plants on the newer cultivation had substantially the greatest number of fruiting nodes, which was significantly correlated with the most shedding.

With the continuation of dry weather through February, varietal and age of cultivation reactions became apparent, and interesting results were obtained in the flower counting for the season. In all treatments the Triumph variety was so significantly ahead in the first three weeks of flowering that it was eliminated when analyzing the data. In this period the data from the slow flowering Indio Acala showed an almost linear regression from the newest to the oldest cultivations. In the second three weeks of flowering the Triumph variety again lead substantially. The effect on this variety of the heavy flowering during the first six weeks of such dry conditions became apparent in the third period of three weeks, however, for Triumph was the only variety in which the flowering was reduced in this period.

The total flowering may be summed up as indicating that the varieties showed the same properties in each age of cultivation, hence no significant interactions were obtained. The relative order of merit of varieties was in keeping with the results obtained in the other tests containing these varieties which were conducted on the Research Station this season, *i.e.*, the quicker flowering varieties produced the most flowers over the total period of counting, and all varieties produced the most flowers on the newer cultivations out of grassland.

The yields of seed cotton obtained, with the exception of one test on land in the second year after three years of Rhodes grass, were in keeping with the flower counts obtained, the total yield per age of cultivation declining in the following order:—(1) Third year out of virgin grassland. (2) Second year following three years of Rhodes grass on old cotton cultivation. (3) Nine years of successive cropping of cotton following virgin grassland. (4) Twelve and sixteen years of successive cropping of cotton following virgin grassland, about equal.

The varietal yields tended to be somewhat irregular, except that Triumph led in all ages of cultivation, and in the analysis of the data the interaction term was not significant, *i.e.*, there was no special response of one variety to certain types of soil. As a whole the three slowest flowering varieties tended to yield less than the quicker flowering varieties. The yield of each variety increased substantially from the two older cultivations to the newest, except in the case of the lowest variety, which yielded the least on all cultivations. This variety experienced a serious loss of crop on the newest cultivation for some unexplained reason.

Combined Varietal Test and Rotational Trial. –The testing of the effect of various cropping rotations on the following cotton crop was modified this season to embrace the Triumph variety as well as Miller, the only variety used in the previous trials for some years. The varieties were planted in a " Student " comparison following Sudan grass, saccaline, continuous cotton, giant setaria, cotton in the first, second and third years after Rhodes grass, and maize after oats. In all comparisons, except one in the second year of cotton after Rhodes grass, Triumph outyielded Miller, the mean yields of 350 and 248 lb. seed cotton per acre being significantly different. No significant trends were obtained as to the effect of the previous cropping, except that where cotton followed a very poor crop of maize which died early in the previous autumn, there was a tendency for the cotton to outyield adjacent areas following either cotton or quick maturing summer fodder crops. Cotton following Rhodes grass, as a whole, tended to yield better than other rotations.

Rhodes Grass—Cotton Rotations.—The value of the Rhodes grass-cotton rotation was tested on several soil types on the Research Station in the following experiments :—

E.10–16.—The soil of this series is a very fertile clay loam which has been under various croppings since 1924. The nitrate content of the surface six inches of this soil usually rises to about 20 to 40 p.p.m. of soil according to the season experienced. In the earlier years of cultivation excellent yields were obtained in this series of plots, but in more recent years low yields have been mostly realized except in very outstanding years. A long term grassland-cotton rotation experiment was therefore designed for this area in which cotton following successive crops of cotton is compared each season with cotton in the first, second and third year after three years' growth of Rhodes grass. Miller, the standard variety for the district, and the early maturing Triumph variety are grown on each age of cultivation.

Weekly flower counts indicated once more the superiority of Triumph under the short seasonal conditions. The order of flowering on the different ages of cultivation was somewhat confusing. Continuous cotton and both the first and second year of cotton after Rhodes grass flowered in keeping with the results obtained in previous dry seasons on such ages of cultivation, the second year leading, followed by continuous cotton and the first year after Rhodes grass. The flowering following the third year after Rhodes grass was lower than where cotton was grown continuously, for which an explanation cannot be offered.

The yields obtained per age of cultivation were in the same order

of merit as the flowering, with the second year after Rhodes grass producing 429 lb. seed cotton per acre—a gain of 127 lb. or 42 per cent. over continuous cotton. Triumph outyielded Miller in all treatments except in the second year following Rhodes grass.

Nitrate determinations made fortnightly in 6-inch zones to a depth of 24 inches throughout the season in the first year following Rhodes grass and in the continuous cotton plots indicated that only a bare trace of nitrates was available in all zones in the former treatment as compared in the latter treatment with as much as 26 p.p.m. of nitrates in the top 6-inch zone and following the copious March rains, 41 p.p.m. in the 20–24-inch zone.

Soil moisture determinations made for the same periods as the nitrate samplings indicated a markedly higher moisture content in the first year following Rhodes grass at the 10–12-inch zone, through most of the critical growing season, but only a slight increase in January and February at the 16–18-inch zone, and no significant differences at the 22–24-inch zone. There was a slight consistent tendency throughout the growing period, however, for the continuous cotton areas to have more moisture at the latter depth, which may be explained by the cotton roots penetrating deeper following Rhodes grass than in the old cotton cultivation.

G.2–10.—This experiment embraces comparing continuous cotton with cotton successively in the first, second and third year following three years' growth of grass. The soil type is a shallow, relatively infertile, sandy clay loam overlying a fine sandy clay subsoil that occurs in sections of the Callide Valley, apparently as a result of the shifting of the stream bed during the formation of the present alluvium. The surface soil sets very hard after a few years of cultivation from the virgin state, and increasing the permeability and moisture holding capacity of the soil is highly essential.

In previous years gains have been obtained on cultivations of various ages following the growth of Rhodes grass, although in dry seasons yields were definitely low on all ages of cultivation. Under this season's conditions yields were again very low and the standard Miller variety produced only 185 lb. seed cotton per acre on cultivation in the second year after three years of Rhodes grass as compared with 139 lb. on continuous cotton cultivation, a gain of only 32 per cent., as compared with 42 per cent. in the fertile soil in E.10–16.

G.11–17.—The soil type of this experiment is similar to that of G.2–10 experiment. Both sites are on a four per cent. slope and in G.11–17 a demonstration of strip cropping with Rhodes grass is conducted.

Size and slope of the area allow of only two strips of grass 50 ft. wide being run on a curved level contour across the field. The cotton rows ran parallel to the strips of grass and in this season were on land in the second year following Rhodes grass, and on old land continuously cropped to cotton. Last season a gain of 297 per cent. was obtained on the land in the first year following Rhodes grass. This season a yield of 450 lb. seed cotton per acre was obtained, compared with 285 lb.—a gain of 57 per cent.

The results realized as a whole from the series of Rhodes grass-cotton rotations, once more indicated the value of this method of cotton-growing. Under the dry conditions ruling, however, further evidence was obtained that it is advisable each season to grow cotton in the first, second and possibly third year after ploughing the grassland, to ensure that a part of the crop will be grown on cultivation of an age well suited for any extreme type of climatic conditions that may be experienced.

Row and Plant Spacing Experiment.—As part of the investigation of the merits of mechanical harvesting, a combined row and plant spacing experiment of a 2×2 factorial design was conducted this season in the Miller variety on four-year-old cultivation after virgin grassland. The normal $4\frac{1}{2}$ ft. row spacing used on the Research Station was compared with the $3\frac{1}{2}$ ft. row spacing required by the harvesting machine, with 1 and 2 foot single-spaced plants in each row spacing.

The dry seasonal conditions markedly restricted plant growth and consequently the order of merit both of the flowering for the first nine weeks and of the total yields of seed cotton obtained per acre, was in keeping with plant numbers, the treatment with the most plants having the highest yield (677 lb. seed cotton per acre), and the treatment with the least number of plants the lowest yield (464 lb. seed cotton per acre).

Counts of both fruiting and vegetative branches were made on forty plants in each plot or 240 plants per treatment. The analysis of variance indicated that plant spacing had exerted a greater influence upon branching than had row space, the 1 ft. spacing having fewer fruiting and also vegetative branches per plant in both row spacings. The means for both classes of branches in this plant spacing in each row spacing closely approximated each other.

Several repetitions of this experiment are required before any safe recommendations may be made, for undoubtedly the dry conditions severely restricted plant growth.

Irrigation Investigations.

The programme of investigations conducted on the irrigation area consisted of the following comparisons :—(*a*) growing cotton with and without supplementary spray irrigation facilities ; (*b*) 3-inch and 6-inch pre-planting spray irrigations, followed by further spray irrigations when required ; (*c*) the furrow and spray methods of applying water ; and (*d*) varieties considered to be the most suitable for growth under spray irrigation facilities.

The soil type of the irrigation area is of a medium loam with a moisture equivalent of approximately 22 per cent. in the upper soils. At a depth of 18 inches the soil tends to become slightly heavier. The first three of the above experiments were conducted on soil in the first year of cultivation out of virgin grassland and the varietal test on second-year cultivation.

(*a*) *With and Without Irrigation Facilities Experiment.*—The experiment consisted of a " Student " comparison of eight pairs of plots. The irrigation plots were planted on October 18th following a 3-inch spray irrigation. Owing to the grasses having exhausted the moisture to practically wilting point for a depth of 6 feet during the dry period from March to August when the ploughing was performed, the depth of penetration of the pre-planting irrigation could be visibly determined. The range of the penetrations varied from 10 to 33 inches, with most sites around 14 to 18 inches. Extremely hot conditions were experienced following planting, making it necessary to irrigate again within three weeks. A 3-inch watering then increased penetration to around 3 feet, the mean at that depth being 16·5 per cent. on the oven-dried soil.

Planting rains for the rain-grown plots did not occur until November 14th ; these plots were planted after 1·21 inches of rain had been received. A further 2·80 inches experienced in the last week of the month satisfactorily established this planting. Flowering commenced on December 14th and January 12th respectively, and by February 1st equal areas of each treatment had produced on the days of observation, 17,430 flowers on the irrigation plots and only 2,060 flowers for the rain-grown plots. During the following period to March 29th the flowering in each treatment was equal, thus indicating that under the seasonal conditions experienced the value of irrigation facilities, as far as flowering was concerned, consisted in enabling the earlier crop to be planted, which flowered appreciably more heavily by mid-season than did the rain-grown crop planted a month later.

The effect of this earlier flowering was reflected in the rates of boll opening, the first picking being completed on March 4th in the

irrigation areas and on April 23rd in the rain-grown areas. The second pickings were completed on April 22nd and May 14th respectively, with a final clean up on the latter date in the irrigation area. The total yields were at the rate of 1,456 lb. seed cotton per acre in the irrigation plots and 420 lb. in the rain-grown plots.

This gain of 1,034 lb. seed cotton per acre was obtained through the application of 11 inches of water in four waterings. The seasonal rainfall and the amounts and times of watering are set out in Table II. There was no soil moisture present in these plots prior to the pre-planting irrigation. It is considered that the yield of the irrigation areas might have been increased somewhat had a break-down of the source of power not prevented the January watering from being given on the first of that month. The delay caused rather severe temporary wilting to occur before that watering was accomplished.

Soil moisture determinations made fortnightly through the season indicated that the subsoils of the irrigation areas of this experiment were not wet to 4 feet until the 2·93 inches of rain received on March 9th, which was preceded by 2 inches of irrigation water applied on February 27th. The moisture content below 3 feet of the rain-grown areas was not increased all the season.

TABLE II.

Half of the Month.	*Oct.*		*Nov.*		*Dec.*		*Jan.*		*Feb.*		*March.*		*April.*		*May*	*Season's Moisture inches.*
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	
Rainfall in inches ...	0·16	0	1·42	2·80	1·28	0·16	2·34	1·58	2·23	0·36	3·82	2·40	0·48	0	0·06	19·09
Irrigation in inches	3·0		3·0				3·0		2·0							11·0
Dates of irrigation	17th		6th				9th		27th							
Total Moisture	0·16	3·0	4·42	2·80	1·28	0·16	5·34	1·58	2·23	2·36	3·82	2·40	0·48	0	0·06	30·09

(*b*) *3-inch versus 6-inch Pre-planting Spray Irrigation.*—The object of this experiment was to ascertain the relative effects of the two rates of pre-planting watering on the subsequent times of watering and the amounts of water applied, and also the resultant growths of plants and yields of cotton produced.

The experiment was planted on October 26th–28th. The 6-inch pre-planting watering increased the moisture content of the second foot of soil over that of the plots receiving the 3-inch watering to such an extent that it was not necessary to irrigate in mid-November the plots that had received 6 inches of water, when a further 3-inch watering was given the companionate plots. There was no significant difference between the two treatments all season in regard to the amount of

subsequent waterings after mid-November, plant growth, flower counts for either the first or second periods of counting, or the final yields harvested.

(*c*) *Spray versus Furrow Irrigation.*—The object of this experiment was to determine the relative costs of application and the yields obtained where these two forms of irrigation were applied on a slight slope just sufficient to allow the water to run down the furrows satisfactorily. A 3-inch spray pre-planting watering was applied to the sprayed areas and an equivalent amount of water per acre was run down the furrows. The pre-planting irrigation penetrated from 14 to 30 inches with the mean approximating to 18 inches, as compared with 25 to 34 inches one foot from the centre of the furrows. This experiment was planted at the end of October and so did not require the second watering given to the other experiments. Only a further 3-inch watering was applied in mid-February to each treatment. No significant differences were obtained between the yields of the experiment, which tended to be somewhat lower than those of the rest of the irrigation experiments. It is possible that under the seasonal conditions it would have been profitable to have irrigated both treatments earlier in February. The furrow form of irrigation proved to be cheaper in that more land could be irrigated in a given time through the elimination of the necessity of stopping the pumping while the spray lines were shifted. The spray form of irrigation does not require even grading of the land, however, and on the soils used a spray application of 3 inches an hour was readily absorbed.

(*d*) *Varietal Test.*—This experiment included comparison of four medium to large boll varieties producing $1\frac{1}{16}$ inch to $1\frac{1}{8}$ inch staple, with Miller, a big boll, 1-inch variety which is the most widely grown cotton in the district.

Moisture determinations made prior to the pre-planting irrigation indicated that the subsoils were well wet to a distance of 6 feet as a result of the good penetrating rains experienced in the previous March. The moisture of the first two 3-inch irrigations wetted the soil to 3 feet where it connected with the subsoil moisture, thus indicating the definite advantage of having not only moisture in the upper soils prior to the pre-planting irrigation, but also in the subsoils to at least a depth of 6 feet. After the 3-inch pre-planting watering further 3-inch waterings were given on November 11th, January 7th and February 18th, or a total of 12 inches for the season.

Plant growth was well maintained throughout, except for a slight checking in early January due to the delay in watering caused through the break-down of the tractor power unit. Flower counts from

mid-December to the end of March, when presented in graph form, depicted most interesting responses to the effects of environmental conditions. A severe drop in the graphs at the end of January may have reflected the effect of the delay in watering early that month. As stated earlier, however, excessively cloudy conditions were experienced at different times during the season. When the cloud condition at 9 a.m. classed on a scale from 0 to 20, was plotted on the graph it was noticeable that throughout the period of flower counting, a rise in the degree of cloudiness over a period of a week was followed by a depression of flowering, and conversely a substantial lowering of the degree of cloudiness for a week or more resulted in a sudden marked rise in the flowering graphs.

The yields of seed cotton per acre obtained from the randomized block experiment ranged as follows :—Indio Acala, 1,679 lb. ; Miller, 1,793 lb. ; Stoneville 5–2100, 1,850 lb. ; New Mexico Acala, 1,843 lb. ; and Farm Relief, 1,909 lb. F for varieties was not significant for the total yield, but was significant at each of the first two main pickings. Farm Relief and New Mexico Acala significantly outyielded Stoneville and Indio Acala at the first picking, but were significantly the lowest pair at the second picking. Miller was just slightly less than intermediate between the lowest and highest yielding varieties at each picking.

Entomology.

Prior to the inception of the programme for 1940–41, the following points had been established with reasonable certainty :—(*a*) applications of lead arsenate do reduce the square and boll loss caused by *Heliothis* ; (*b*) the beneficial effect of such protection may not be shown in the final yields unless subsequent climatic and soil conditions are favourable for the retention and maturation of the bolls ; (*c*) these conditions are more usual in irrigated than in non-irrigated cotton. The main insecticidal experiment was therefore located on the irrigated settlement at Theodore in order that the true effect of spray schedules in controlling *Heliothis* might be expressed in terms of yields.

To simplify matters, only one insecticide, containing 1 lb. lead arsenate, 1 gal. molasses and 6 gal. water, was used. Six treatments were selected in order to determine the optimum period for spraying. Two of these were routine applications of the spray from the time of first flowering ; two more began a fortnight after first flowering ; while a third pair began one month after first flowering. In each pair, one treatment was applied at fortnightly intervals and the other at monthly intervals.

The incidence of *Heliothis* was not particularly heavy, though egg

counts did at times reach levels indicative of pending severe injury. These levels were recorded in November and December. It is not surprising therefore that increased yields were obtained only from treatments begun at the time of first flowering, and that fortnightly treatments were more efficient than monthly treatments. It is also in conformity with the incidence of the pest that the increased yields were obtained largely in the first pick, though to a lesser extent in the second pick also. In the third and final pick, the control plots out-yielded the treated plots, though not sufficiently to compensate for the increased yields obtained from the treated plots in the first and second picks.

The relatively heavy crop set by the control plots late in the season suggests that on these soils at least, *Heliothis* injury in early and mid-season is to some extent followed by abnormally heavy bearing later on. For this to happen, the time factor is important and the phenomenon could only occur in early planted crops which have a reasonably long growing period ahead of them before further development is inhibited by frosts. This conclusion is in conformity with the known fact that early planting is a tolerably effective method of escaping crop losses due to *Heliothis*. The maximum contribution to crop yields from insecticides would consequently be expected in late-planted crops, though it is a moot point whether the protection given to such crops can ever be good enough to outweigh the incidental benefits attributable to early planting.

Observations on square and flower counts, though not sufficiently detailed for statistical study, suggest that arsenicals tend to reduce the fruiting capacity of the plant, though this is usually obscured in the final yields by the protection given to the squares and bolls actually formed. These observations may shed some light on the results obtained at Biloela in 1939–40, when yields from dusted plots in non-irrigated areas were significantly less than in the controls—*Heliothis* infestation having been negligible.

The scope for maize trap crop methods of protecting cotton from attacks by *Heliothis* were further tested during the year in several districts. The pest was more active than for some time past and it was therefore possible to obtain more satisfactory data than in earlier experiments. The tentative conclusions are (*a*) that present methods in which 6 per cent. of the acreage is sown to maize in three plantings at three week intervals from the time the cotton is sown, may prove ineffective when *Heliothis* populations are high ; (*b*) that improvements may be effected by increasing the area of maize planted three weeks after the cotton, *i.e.*, maize which tassels when *Heliothis* populations

are normally at their peak, and (*c*) that the maize trap crop method finds its maximum utility in non-irrigated cotton grown in land which has already been cropped once after having been grassed for some years, *i.e.*, land in which the weed problem is unlikely to be serious, and an even growth of maize can be expected.

A survey of cotton pests during the season indicates that *Pectinophora scutigera* Hold. was very common in central Queensland late in the season and appreciably depressed yields; most of the outbreaks were localised and adjacent to areas of rattoon or standover cotton. In the Callide Valley *Antarchaea chionosticta* Turn. was so widespread and destructive early in the year that lead arsenate sprays were used on an unprecedented scale for its control; as with *Pectinophora*, these outbreaks were mostly confined to farms in the vicinity of standover or rattoon cotton. Jassids were more widespread and destructive than for years past; some areas where this insect has been more or less innocuous in the past were subjected to severe attacks. *Heliothis* was particularly important in southern and coastal Queensland, where early summer rains hampered farming operations designed to control weed growth. Infestation was of the "spot" type and in some cases very destructive.

EXPERIMENTAL PROGRAMME FOR THE SEASON 1941-42.

The proposed programme for 1941–42 comprises the following features :—

Plant Breeding.—(*a*) A continuation of the backcrossing work which includes studying the progenies of the third generation of backcrosses for uniformity of characters, jassid resistance, etc.

(*b*) Testing a comprehensive range of new and old open pollinated material obtained in jassid-infested crops.

Experiments.—A continuation of the general programme conducted during the season under review with various modifications to meet the Staff situation and to embody amplifications based on the findings of the season.

Entomology.—The programme for the year will have as the main points for elucidation :—

(*a*) The contribution made by each spray application in a number of *Heliothis* control schedules to the final increase in yield;

(*b*) the reduction in square and boll losses brought about by each spray application ;

(*c*) the effect of lead arsenate sprays on the fruiting capacity of the plant ;

(*d*) the relative value of *Heliothis* control schedules in early and late planted crops ;

(*e*) the significance, if any, of early square loss due to *Heliothis*, on the capacity of the plant to mature squares produced later in the season.

SOUTH AFRICA

PROGRESS REPORTS FOR THE SEASON 1940-41.

INTRODUCTORY NOTE

BY

F. R. PARNELL.

Staff.

Barberton.—All officers of the Insect Pest Control Section were on military duty throughout the season and the section was closed down.

In the section of Plant Breeding and Field Experiments, Mr. MacDonald was the only member of the staff remaining, but I was able to devote time to this work with him.

Swaziland.—The position here remained the same as last season, with both officers working under the Administration, Mr. Lochrie continuing his experiment station work and Mr. Hutchinson taking charge of native cotton-growing and assisting in a Food Production scheme.

Commercial Crop.

There was a small increase in the crop in the Barberton area, but the production for the whole country will probably be about the same as last year. Prices realized were rather better and an increase may be expected in the coming season if planting rains are good.

There is some interest being taken in the possibility of starting a cotton spinning industry on a small scale in the Union and if this should develop it would undoubtedly encourage production.

Native Cotton.—With Mr. Bowmaker's departure the work of our staff in Natal came to end, but a new start was made with native cultivation in Swaziland. There is no doubt that cotton could take a useful place in the native agriculture there and, although the total production would never be on a really large scale, it might be of great value to the country.

In many ways the start has been promising, but it will be an uphill task and satisfactory progress will be impossible unless the Chiefs concerned, both big and little, can be induced to interest themselves in the building up of a sound system of agriculture.

Experiment Stations.

The work at Barberton was much curtailed, but less so than had been expected and some very useful results were obtained. The most outstanding material on the breeding side was that derived from U.4 × Cambodia crosses, of which a large area was grown. This is extremely promising.

The crop again closed down early, but this year there was no evident cause. The results reported indicate that nitrogen-starvation was not responsible and some other cause must be sought.

The section on Plant Pathology relates to work carried out in the previous season and has been prepared by Dr. Wickens in his spare time, whilst on military service. It is uncertain when this work will be continued and it is fortunate that the results to date have been put on record. The very strong indications of varietal variation in susceptibility to external boll disease are of great interest, but further work on more normal material is required to confirm the differences actually recorded.

In Swaziland much attention was given to problems of soil fertility, since improvements in this respect are very pressing needs of the country. It is evident that the different types of soil require different treatment and the re-designed manurial experiments now being undertaken should throw more light on the whole problem.

The results being obtained on the worn-out native land at Croydon show what a vast improvement can be effected by a little care and attention.

COTTON EXPERIMENT STATION, BARBERTON.

COTTON BREEDING AND FIELD EXPERIMENTS

BY

F. R. PARNELL AND D. MACDONALD.

INTRODUCTION.

The programme of work carried out during the season was less than usual as a result of the departure on military service of three members of the staff of this Section. Part of the reduction consisted of the non-duplication of the experiments on both granite and loam soils that had been customary in the past, the granite soil section having been put under a resting crop. Apart from a further 12 acres of resting crop, the main area of the Station, on the loam soil, was planted much as usual.

Breeding work on pure U.4 material was cut down considerably, being confined to one variety trial and the multiplication of promising strains suitable for local conditions, The major portion of the time

was devoted to hybridization work, but a few other experiments were also carried out.

Much of the cotton crop gave only moderate yields owing to its early closing down, for which the reasons are not yet understood. There was no serious insect damage during the season.

METEOROLOGY.

The season's rainfall of 33·01 inches, though less than for the previous two seasons, was still above the average for the Station. Rains in September and October enabled seed beds to be prepared early. A portion of the cotton crop was planted in October, and the remainder in the first week of November, excellent stands being obtained from all plantings. Apart from rather excessive rains in November and December, amounting to 15½ inches, the distribution was rather better than usual, while good rains in mid-April were very beneficial to late-planted cotton in the area.

A hailstorm that missed the greater part of the Station damaged the permanent compost trial seriously and affected the variety trial to a smaller extent. Temperatures were more steadily high than usual throughout the season, the monthly mean maxima for the six months, November to April, ranging from 84·2°–87° F. (mean 85·4°), and the mean minima from 60·1°–65·7° F. (mean 63·4°). There was no appreciable general fall in temperature till towards the end of June.

AGRICULTURE.

Rotation Experiment.—The long-term rotation experiment, started in 1932–33, was completed and a full report of the results obtained during the course of the experiment is included as an Appendix to this report.

Compost Experiment.—The compost experiment, on a two-course rotation of maize and cotton on a poor field of loam soil, was again under cotton. The treatments were dressings of compost at 7 tons and 3½ tons per acre and nil. A hailstorm damaged the crop and prevented accurate yield figures from being obtained. Green weight samples of the young cotton, taken at 44 days old, showed those from both the compost dressings to be significantly heavier than nil and those from the 7 ton to be significantly heavier than from the 3½ ton dressing.

GENETICS AND BREEDING.

Variety Trials.—Only one variety trial was planted, comprising strains showing promise under local conditions. Stand and growth were good, but some damage was caused by hail and the crop closed

down early, giving poor yields ranging from under 200 lb. to 237 lb. lint per acre. As in previous poor seasons, some of the re-selections from 5143, the strain in general cultivation in the area, gave significant increases over their parent, as did several selections from the 920 and 921 families.

Hybridization.—Brief references to hybridization have been made in previous reports. This work has now been expanded and details regarding the objects in view are given in the Programme for 1941–42.

Crosses within U.4.—Two U.4 strains, 5143 and 5149, sister strains from 052, have differed consistently in that the former gives a stronger plant, with higher yield in poor conditions, but with rather shorter lint and lower ginning percentage than the latter. Their derivatives have shown the same differences. The best 5149 selection, 8161, was crossed with two good 5143 lots, 6128 and 8202, in 1938–39, and the F_2's were grown in replicated plots alongside their parents in the present season. A storm shortly after germination damaged the stand and made accurate comparisons of plant behaviour and yield impossible. A number of well developed typical plants was taken from each lot at the end of the season for laboratory analysis and the figures obtained are given in Table I.

TABLE I.

Strain.	*No. of Plants.*	*Ginning %.*	*Weight 100 seeds.*	*Lint Length.*
			grms.	*mm.*
(5143) 6128	24	35·4	9·8	31·5
6128×8161 F_2	35	37·1	9·8	32·1
(5149) 8161	24	37·6	9·5	33·0
8202×8161 F_2	35	37·3	10·0	32·3
(5143) 8202	24	36·4	10·1	31·7

It is obvious that 8161 has raised both the ginning percentage and lint length in the crosses: it remains to be seen whether a stable strain can be obtained combining these improvements with the better plant of the 5143 family.

U.4×Cambodia.—The main object of this cross, made in 1937–38, was to combine the greater hairiness of the Cambodia plant with the good characters of U.4, thereby obtaining increased resistance to jassid and possibly to *Lygus*. The material comprised:—

(*a*) (5143 × Cambodia) × 5143, grown for the second season. 5143 × Cambodia, F_2.

(*b*) Two similar lots with 5149 as the U.4 parent.

The above four lots were grown in large plots, alongside small plots of the three parents, replicated four times over 10 acres. Growth was good and this was the best block of cotton on the Station.

By flowering time big differences were apparent between the 5143 and 5149 lots, the former giving better plant development and much

greater hairiness. This confirmed a similar difference seen in the same backcrosses in the previous season. It was decided not to discard the 5149 lots at that stage, however, in view of the better laboratory analysis given by that strain. From all four lots selections were made of plants showing good field characters combined with good hairiness. In judging plants for hairiness they were classified by eye into a number of grades, the main criterion being density of hairs on stem, petiole and leaf, though length did undoubtedly affect the judgment to a small extent. The groupings for the different lots are given in Table II, 1+ representing the greatest and 4+ the least degree of hairiness.

TABLE II.

GRADES OF HAIRINESS.

Cross.	*No. of Plants.*	1+ (*Highest*).	1	2+	2	3+	3	4+ (*Lowest*).
(C×5143)×5143	184	5	28	39	91	11	10	—
C×5143 F_2 ...	113	—	2	23	54	27	7	—
(C×5149)×5149	135	—	2	3	24	63	43	—
C×5149 F_2 ...	170	—	2	—	12	78	68	10

Cambodia=3+, with more of 3 than 2.
5143 =4+ to 3, with more of 3.
5149 =4+ to 3, with more of 4+

The greater hairiness of the 5143 lots is very marked and they contain many plants far more hairy than the Cambodia parent. In both cases, though to a smaller extent in the 5149 lots, the backcrosses are better than the F_2's, but it should be noted that the classification applies only to the selected plants and does not cover the full range of the lots.

The 5143 lots maintained their superiority over the 5149's throughout the season and did not close down so rapidly, but laboratory analyses were carried out for all. Table III gives the mean figures for selected plants in the separate lots, together with parental figures.

TABLE III.

Cross.	*No. of Plants.*	*Yield per Plant. gms.*	*Boll Weight. gms.*	*Ginning %*	*Weight 100 seeds. gms.*	*Lint Length. mm.*
(C×5143)×5143 ...	184	222	5·3	36·6	9·5	31·2
C×5143, F_2	113	187	5·7	35·5	10·1	31·1
(C×5149)×5149 ...	136	174	5·5	36·1	9·4	30·2
C×5149, F_2	171	144	5·4	35·7	9·4	30·7
5143	Bulk	—	—	36·6	9·2	31·0
5149	do.	—	—	37·9	9·1	32·8
Cambodia	do.	—	—	34·9	11·0	29·5

These are excellent records for the 5143 lots, particularly the backcrosses, which combine a hairiness greatly exceeding that of Cambodia with ginning percentage and lint length equal to the U.4

parent. The very high mean plant yield was due more to good fruiting than size of plant, though the plants were generally well grown.

It will be seen that the 5149 crosses have not given a better ginning percentage and lint length than the others as had been expected, moreover their yields are poorer. Their main justification thus disappears and only 30 of the best plants will be carried forward. Of the 5143 lots, 100 single plants from the backcrosses and 50 from the F_2 will be planted in the coming season. This material is extremely promising.

Correlation tables for various characters in the above crosses showed the two groups behaving differently. Both 5143 lots showed no trace of correlation between lint length and degree of hairiness, but a slight negative correlation between lint length and ginning percentage. The opposite was the case in the 5149 lots, where lint length was not correlated with ginning percentage, but showed a very slight negative correlation with amount of hairiness. A grading of the 5143 backcrosses for earliness of fruiting showed no correlation between this character and lint length.

In the 1939–40 season a few very hairy plants in each of the above backcrosses were backcrossed again by the best re-selections from their respective U.4 parents. These plots were damaged by a storm shortly after germination and bulk pickings only could be made for planting again in the coming season.

U.4×M.U.8A.—The latter strain, a Malwa Upland type sent from Indore by Hutchinson, is by far the hairiest *hirsutum* that we have been able to find. It would grade as something better than 1+ of Table II. It may be noted that its hairiness appears to have increased during some years of acclimatization at Barberton and new seed has been obtained to test this point critically.

Crosses of this strain with U.4 were backcrossed to U.4 this season and the backcross and F_2 will be grown alongside the parents in the coming season.

Quality Crosses.—An attempt is being made to obtain a type combining the general characteristics of the U.4 plant with finer lint than can be got inside this family. A collection has been made of the finest linted types of *hirsutum* available, for use as parents in this work. Sea Island and Egyptian are also being used, though genetic difficulties may render these inter-specific crosses less profitable.

F_1's of U.4×V.135 (S. Island) and U.4×X1530 (Egyptian) were backcrossed to U.4 in the present season. Of fine-linted Uplands, Coker and Acala were both crossed by U.4 (5143) and M.U.8A. Crosses with other Uplands will be made in the coming season.

EXPERIMENTS.

Crop Development and Loss.—The experiment carried out and reported last season was repeated in the same manner, with the difference that five repetitions were used instead of ten and the sample for recording was 100 plants instead of 200. The strain used was 8199, an earlier and rather less robust type than the 6128 of last season.

Briefly, a weekly count was made throughout the season, on a sample of 100 plants, changed weekly, of all buds, shed points and bolls. The division of shed points into shed squares and shed bolls was based on the analysis of shed material from a separate sample of 400 plants, collected every second day. The fruiting analysis is shown graphically in Fig. 1, which also gives the daily rainfall for the period.

The curves generally are very similar to those for last season, (*vide* " Reports from Experiment Stations," 1939–40, p. 16.) There is the same sudden break in the production of fruiting points midway through the season, but this year the shed bolls form a greater proportion of the shed points. The percentage of bolls held would have been lower, about the same as last year, if records had been continued for a further week or two.

The sudden cessation of square production last season was attributed to drought, but moisture was good when the break occurred this season and some other cause must undoubtedly be sought. Further reference to this abrupt " closing down " will be made in discussing the Nitrate experiment. The slightly greater rise in square production after the break and the smaller proportion of shed squares this season may well be the result of better moisture conditions.

The whole crop closed down rapidly and leaf-fall associated with *Alternaria* was severe. This completely masked any " handling effect " that there may have been : there was no difference in yield between handled and non-handled rows, since the extra late bolls that might have been obtained from the latter failed to mature.

Analysis of shed material showed bollworm to be mainly responsible for the small loss in January. For the greater part of February bacterial disease was the chief cause, but the heavy later shedding appeared to be physiological. Boll shedding, other than through bollworm, occurred mainly at 7–10 days from setting, and squares over a fortnight old seldom shed unless damaged by insects.

Premature Leaf-Fall.—Numerous references have been made in past reports to the early closing-down of the crop, with premature leaf-fall associated with *Alternaria.* This fungus is normally only a weak parasite, and it has already been shown (1938–39 Report, p. 20), that it does not develop in, or damage, the leaves of healthily growing

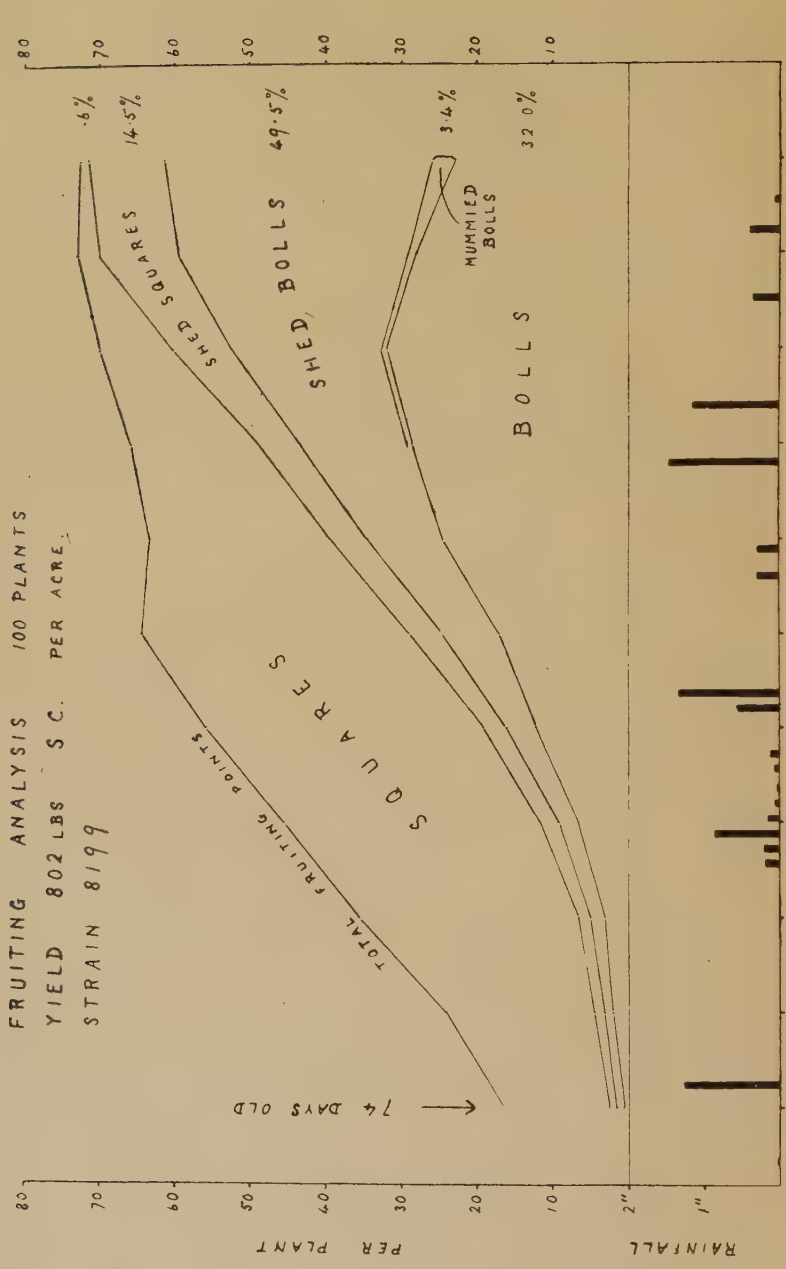


FIG. 1.
FRUITING ANALYSIS 100 PLANTS
YIELD 802 LBS S.C. PER ACRE
STRAIN 8199
TOTAL FRUITING POINTS
14 DAYS OLD
SQUARES
SHED SQUARES 14·5%
SHED BOLLS 49·5%
MUMMIED BOLLS 3·4%
BOLLS 32·0%
·6%
PER PLANT
RAINFALL
1"
2"
JAN.
FEB
MCH.

cotton. What causes the " debility " in our crop towards the end of the season that so often allows this disease to develop, giving premature leaf-fall and loss of the late bolls ?

This type of leaf-fall is confined to the red loam soil of the Station, derived from diorite, and does not appear on the granite soil. It is far less common in the surrounding district, though it occurs occasionally on various types of soil. It was first seen on the Station in the 1928–29 season and has occurred irregularly since, becoming more general in recent years. We have been unable to correlate it with any known factor of climatic or other conditions.

Edge plants bordering on open space always finish better, generally remaining very markedly greener than plants inside the plot. This suggests competition for plant food or moisture, but it has happened at times when moisture was good ; thus lack of moisture is not a constant factor of the debility. This also follows from the fact that a very well grown crop, though requiring more moisture, retains its leaf better than a poor growth.

No manurial treatments that we have seen have prevented the sudden leaf-fall with *Alternaria*, though such as have led to visibly better growth have retarded its onset. This applies to applications of nitrogen, potash, phosphate and kraal manure in various combinations. Applications of the minor elements, boron, copper, magnesium, manganese and zinc, have been tried in various combinations : not the slightest effect on the cotton could be detected in any treatment, but it was a year in which *Alternaria* did not develop.

All varieties are affected in the same manner, except that later-fruiting types hold out longer. Heavy and early fruiting undoubtedly predisposes a plant to this early leaf-fall.

Examination by Wickens has failed to reveal the presence of wilt or root disease in the affected plants.

Whilst manurial treatments in the past have failed to throw light on the problem, it is still possible that faulty nutrition, at the critical time of rapid boll development, may be the main factor involved. Crowther has shown (*Annals of Botany*, Vol. XLVIII, 1934, p. 892) that in the Sudan serious nitrogen starvation of the leaf occurs at this time. A nitrate trial carried out here last year (1939–40 Report, p. 18) failed in its full purpose because a drought rendered ineffective the late application. A more detailed experiment was carried out in the present season.

Nitrate Trial.—The object of the experiment was to determine the effect of applications of nitrogen at different times on the fruiting of cotton, its susceptibility to premature leaf-fall and the nitrogen content

of various parts of the plant at different stages of its development.

The experiment was carried out on loam soil that had received a uniform dressing of 3½ tons compost per acre (equal to about 35 lb. nitrogen) at the end of the previous season. A randomized block lay-out was used, giving 10 repetitions of the four treatments below :—

1. Medium ... 200 lb. per acre nitrate of soda as a top dressing at eight weeks (3rd January).
2. Medium + Late 100 lb. at eight weeks + 100 lb. at 12 weeks.
3. Late ... ... 200 lb. at 12 weeks.
4. Nil.

Two strains of cotton were employed, 6128 and 920, each manurial plot comprising four rows of each strain 76′ in length, the two adjacent rows of each strain being used for records.

Five blocks were reserved for yield data, flower counts on one row of each strain per plot, and sampling for nitrogen determinations. On the other five blocks a 10% sample was used for regular records on the production of squares, flowers and bolls.

In all the fruiting records made, including yield figures, there were no significant differences between treatments. Growth was somewhat patchy and the figures were not regular enough to detect small differences with accuracy, but there appeared to be no indication of any consistent treatment effect. On the sample plants the late application gave the highest figures for total squares, flowers and bolls produced, but this superiority was already evident in the records of the first three weeks before the dressing was applied, and may be disregarded.

In the previous season nitrogen applications increased the boll weight appreciably ; here in both strains the differences were small and not significant.

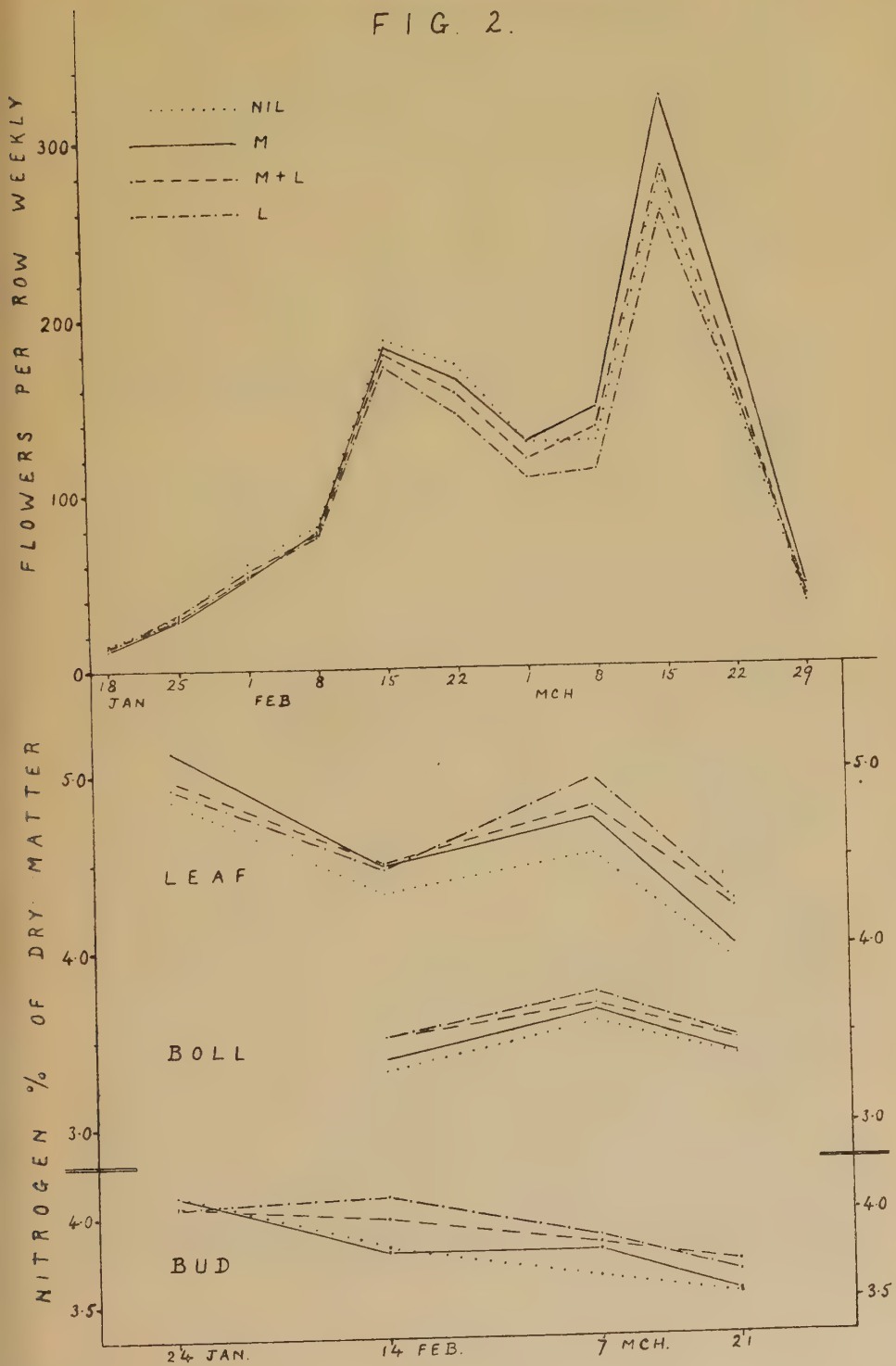
Curves for the flower counts on whole rows are given in Fig 2 (p. 29), mean figures for the two strains being used as they behaved similarly. It will be seen that the general behaviour of all treatments is remarkably similar. No nitrogen treatment has altered the early flowering or postponed the rapid falling off at the end. The greatest differences occurred in the three weeks covering the second peak of flowering, but they were not significant.

The trough in the curve appears to have been due to rather lower temperatures over the three weeks concerned, compared with those of the previous and succeeding weeks, a difference of 6° F. on the means.

It was impossible to detect any differences between treatments either in their manner of closing down or in the time at which this occurred.

Nitrogen Content.—We are much indebted to the Officer-in-Charge,

FIG. 2.


NIL
M
M+L
L
FLOWERS PER ROW WEEKLY
300
200
100
0
18 JAN
25
1 FEB
8
15
22
1 MCH
8
15
22
29
NITROGEN % OF DRY MATTER
5·0
4·0
3·0
4·0
3·5
LEAF
BOLL
BUD
24 JAN.
14 FEB.
7 MCH.
21

Division of Chemical Services, Pretoria, who very kindly undertook the whole of this analytical work.

Duplicate samples of leaf, bud and boll, from each treatment and each strain in the above experiment, were taken at four successive stages in the season, covering a period of eight weeks :—

Leaf.—40 per sample ; first fully grown leaf of normal colour below growing point, lamina only.

Bud.—50 per sample ; taken the day before due to flower ; bracts removed.

Boll.—No first sample ; 50 per sample ; seven days from flower opening ; bracts removed.

The nitrogen percentages of dry matter are shown graphically in Fig. 2, below the flowering curves and on the same date scale. The two strains behaved similarly and each point represents the mean of duplicate samples of each.

The nitrogen content of the leaf shows a fall for the whole period, 4·97%–4·11% for all treatments, but with an appreciable rise in the second three weeks. It is noteworthy that this rise occurred when flowering was falling off and was succeeded by a relatively steep fall during the late burst of flowering. The treatment effects are appreciable, and as would be expected, the *medium* dressing increased the content more at the earlier dates and the *late* dressings at a later stage.

Unfortunately flowers were not tagged in time for the early sample of bolls. The content of the later samples was roughly 1% lower than that of the leaf. Again, a rise occurred in the second three weeks, but the fall that followed only brought it down to the original level. Treatment effect is smaller than in the case of the leaf, but otherwise very similar.

The nitrogen content of the buds, which was slightly higher than that of the bolls, showed a small steady fall throughout the period, 4·09%–3·61% for all treatments, with no rise in the middle. All treatments started equal but the later dressings showed a smaller fall.

These results are clearly very different from those obtained by Crowther (*l.c.*) in the Sudan and it appears that his general nitrogen level is very much lower than ours. Taking his 3rd–7th samples to correspond with our period of eight weeks, his *green leaf* nitrogen contents were much lower to begin with and fell more rapidly, even in the high nitrogen plots. His heavy application, about 575 lb. per acre of ammonium sulphate, gave nitrogen contents of 3·5%–2·5% for that period, compared with 4·97%–4·11% for all treatments in our experiment. It should be noted, however, that our samples included comparatively young, though fully developed, leaf only, and are thus

not strictly comparable with Crowther's samples of all ages. On the other hand our *buds*, which were all old, showed much the same differences from his samples of all ages. The corresponding figures were 3·5%–2·25% for his best treatment, against 4·09%–3·61% for all treatments with us. For both leaf and buds our low figure at the end of flowering was higher than his high figure before the main flowering had started.

Crowther indicated 2·5% as a critical level for nitrogen content, below which functional disorders arise. In no case in our experiment was there any approach to so low a figure.

(Parsons suggested in last year's report from this Station (1939–40 Report, p. 50) that low nitrogen content of the later buds might be the cause of malnutrition, and hence of the high mortality, in the second generation bollworm larvæ here. The above results do not support this suggestion.)

On our last date of sampling the crop was already showing a slight change of colour, the sign of premature closing down, and it was for this reason that the last interval between samples was cut down to two weeks instead of three. A week later the leaf was definitely deteriorating and *Alternaria* was developing rapidly. In view of the high nitrogen content of leaf, buds and young bolls when the plant started to close down, it is clear that the " debility " of the plant was not caused by nitrogen starvation.

Nitrogen determinations were also made on leaf samples from other material, cotton under three pairs of conditions being selected where one of each pair was expected to close down earlier than the other. In all cases duplicate samples of 100 or more leaves each were taken when the plants had almost finished flowering and were carrying many fully grown bolls, at about 4½ months from planting and one month before first picking.

Details of these lots and the results obtained are given in Table IV.

It should be noted that for pairs 2 and 3 the leaf taken was the same as in the nitrate trial, viz., the first fully-grown leaf of normal colour below the growing point. In the first pair the next below that was taken in addition (two leaves per plant). This may account partly for the higher leaf weights and lower nitrogen contents in the latter pair.

In the first two pairs the " B " crops, which closed down prematurely, show a lower nitrogen content than the corresponding " A " crops, in addition to a lower leaf weight. On the other hand, 3B, of much lighter growth and lower leaf weight than 3A. finished well and gave the same nitrogen content.

TABLE IV.

NITROGEN CONTENT OF LEAVES AND LEAF WEIGHT OF CROPS SHOWING DIFFERENCES IN "CLOSING DOWN."

No.	*Strain.*	*Crop and Treatment.*	*Behaviour.*	*Leaf Weight Dry. gms.*	*N. % on Dry Matter.*
1 A	8199	C.E.S. Loam; Multiplication Plot; Edge Plants.	Good growth and crop; finishing well with healthy green leaf.	·480	3·42
1 B	do.	Do. Inside Plants	Moderate growth and crop; very bad finish with premature leaf shedding.	·349	3·22
2 A	6135	C.E.S. Loam; Rotation Expt.; following Fallow.	Good growth and crop; finishing well; leaf going off as crop ripened.	·446	3·78
2 B	do.	Do. following Sunflower ...	Moderate growth and crop; bad finish with premature leaf shedding.	·334	3·36
3 A	5143	Spear's Farm, after heavily manured tobacco; coarse red soil of mixed origin.	Very good growth and very heavy crop. Excellent finish, with green leaf retained till after picking.	·394	3·60
3 B	do.	Evans' Farm; poorish sandy soil, never given nitrogenous manure.	Light growth; fair crop; finishing well; leaf going off as crop ripened.	·294	3·61

There is obviously a connection between nitrogen content and premature leaf-fall, but all the evidence points to the conclusion that the lower nitrogen content is an *effect* rather than a *cause* of debility in the plant. Thus, No. 3A on Spear's farm, which was extremely healthy to the end and finished exceptionally well, gave a nitrogen content of 3·60% in the leaf, compared with 4·11% for all treatments on our nitrate trial at a comparable stage and when the crop was already showing signs of premature closing down.

ROTATION CROPS.

The season was favourable for rotation crops and yields were good, maize giving up to 2,500 lbs. per acre and groundnuts 2,250 lb. of unshelled nuts. Soya and tepary beans also yielded well.

No experimental work was carried out on rotation crops, but bulks of streak-resistant maize were multiplied. The most important of these were two bulks of Peruvian and Hickory, derived from intra-varietal crosses of selected strains. The incidence of streak disease during the season, though not very severe, was sufficient to demonstrate the high resistance of these bulks. Rogueing for streaked plants was carried out before flowering, practically nothing coming from Peruvian and very few plants from Hickory. These new bulks will be tested for yield against their parent strains in variety trials in the coming season.

Multiplication was also carried out of inter-varietal crosses between resistant strains of Peruvian and Hickory.

The granite soil section of the Station, together with 12 acres on the loam, was planted with pigeon pea, *Cajanus indicus*, as a resting crop. The crop grew very well indeed and proved very effective in suppressing weeds. It has been ratooned and gave a high weight of green material, which has been found very useful both as cattle food and for compost making.

SUMMARY.

1. With the reduced staff less work could be undertaken, but the programme drawn up was carried out in full.

2. The rainfall of 33 ins. was slightly above the average and was fairly well distributed. Some damage was caused by hail and other storms, but stands were generally good. Damage due to insects was negligible, but much of the cotton closed down prematurely and the yields from such fields were moderate.

3. One variety trial was carried out and several of the newer strains gave significantly higher yields than 5143, the strain in general cultivation.

4. Much time was devoted to the following hybridization work :—

(*a*) Crosses inside U.4, between strains 5143 and 5149, to combine the strength of plant and high yield of the former, with the longer lint and higher ginning percentage of the latter.

(*b*) U.4 × Cambodia, F_2's and backcrosses, using 5143 and 5149 as the U.4 parents. The 5143 lots particularly gave excellent material, much of it greatly exceeding the Cambodia parent in hairiness and giving a very good field and laboratory record.

(*c*) Backcrosses were made with U.4 on to F_1's of U.4 crossed with Sea Island, Egyptian and an extremely hairy Indian Upland, M.U.8A from Indore.

(*d*) A beginning was made with crosses of U.4 strains and M.U.8A on to the finest linted Upland types obtainable.

5. A crop development and loss experiment was carried through for the second season in succession. Results were very similar to those of last year, a distinct break in the production of buds occurring at mid season, but with no drought this year to account for it.

6. In a nitrate trial on good soil applications at different times during the season gave no appreciable effect on the production of buds, flowers, bolls and final yield. All treatments closed down prematurely in exactly the same manner.

Determinations were made for us by the Division of Chemical Services, Pretoria, of the nitrogen content of leaf, bud and boll at

various stages of the plant. The nitrogen contents were high and the fall during the flowering period not enough to suggest nitrogen starvation as a cause of debility leading to attack by *Alternaria* and premature leaf-fall.

7. Nitrogen determinations on other material showed the content of the leaf of an extremely healthy crop on another farm to be lower than that of the crop which closed down prematurely in the above experiment.

8. No experimental work was carried out on rotation crops, but certain strains of streak-resistant maize were multiplied and rogued.

9. The season was favourable for rotation crops and goods yields of maize, groundnuts, soya and tepary beans were obtained.

10. The long-term rotation experiment was brought to a close and the results are included as an appendix to this report.

PROGRAMME OF WORK FOR 1941-42.

Cotton Breeding.

Variety Trials.—One ordinary variety trial will be planted with the most important and more recent derivatives of U.4.

A special small trial will be conducted which, in conjunction with a similar trial at Domira Bay, is intended to indicate whether the poorer spinning quality of lint from that area is due to intrinsic strain differences or to the effect of the differing conditions of the two areas. The strains used will be 920 Bulk, as modified at Domira Bay, together with one of its derivatives from there, and the ordinary Barberton 920 Bulk and one of its derivatives.

Hybridization.

U.4 Material.—The crosses between derivatives of 5143 and 5149, to combine the strength of plant and high yield of the former with the longer lint and higher ginning percentage of the latter, will be continued.

U.4×Cambodia.—This cross was made in 1937–38, primarily to improve the hairiness of U.4. The resulting material, described in the report for 1940–41, contains many excellent types with far greater hairiness than the Cambodia parent. Several bulks and 180 single-plant selections will be carried forward.

U.4×M.U.8A.—The latter strain, a Malwa Upland type sent by Hutchinson from Indore, is extremely hairy, surpassing all Upland

types seen here. It is strong and tough, though of moderate size, and yields well, but the lint is short and harsh.

Backcrosses to U.4 and the F_2 will be planted.

Quality Crosses.—Several crosses have already been made, and more will be made in the coming season, in an attempt to combine good "quality" of lint and a high degree of "hairiness" of the plant, in a type of plant suitable for Tanganyika and the countries of Africa further south. This means a type possessing many of the general characteristics of U.4 with finer lint and, if possible, greater hairiness.

A collection has been made of the finest linted *hirsutum* types available, for parents in the main work. In addition, Sea Island and Egyptian are also being used. The opposite parents will be U.4 strains and M.U.8A primarily.

It is not the intention to produce finished strains, for trial in other countries with a view to adoption as they stand. It is rather to produce a number of types in which the general characters required are combined, but which still possess considerable genetic variance, for use as raw material for selection in any area in which they are generally promising.

COTTON EXPERIMENTS.

Premature Leaf-Fall.—A manurial trial will be carried out to see the effect on the premature closing down and development of *Alternaria*, of heavy dressings of potash and lime in various combinations with compost and nitrate. Early experiments showed no effect from moderate applications of lime, but a considerable amount of superphosphate has been used in later years and it is possible that the soil is becoming too acid.

ROTATION CROPS.

Maize.—Variety trials will be carried out to compare the streak-resistant crosses of Peruvian and Hickory with ordinary bulks of these two strains, separate trials being planted on two different dates.

Seed of the above crosses, for the planting of observation plots, has been distributed to farmers whose maize commonly suffers from streak disease.

Rotation Experiment.—The second half of this experiment, which was finished this year, will be planted uniformly to maize to see the residual effect of the rotations on this crop.

COTTON EXPERIMENT STATION, BARBERTON.

DAILY RAINFALL, SEASON 1940–41.

	July	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*
1	—	—	—	0·04	—	0·17	—	0·12	—	—	—	—
2	—	—	—	—	0·15	—	—	—	—	—	—	—
3	—	—	—	—	0·84	—	—	—	—	—	—	—
4	—	—	0·05	—	0·06	—	0·02	0·55	—	—	—	—
5	—	—	—	0·01	—	—	—	1·33	—	0·02	—	—
6	—	—	—	0·73	—	—	—	—	0·36	0·79	—	—
7	—	—	—	0·22	0·12	—	—	—	—	1·04	—	—
8	—	—	0·19	—	0·41	—	—	—	—	0·52	—	—
9	—	—	—	—	0·75	0·10	1·26	—	—	—	—	—
10	—	0·07	—	—	2·07	—	—	—	—	—	—	—
11	—	—	—	—	0·80	—	—	—	—	0·07	—	—
12	—	—	—	—	0·01	—	—	—	0·41	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—
14	—	—	0·05	—	—	0·04	—	0·30	0·07	—	—	—
15	—	—	0·03	—	—	0·78	—	—	—	—	—	—
16	—	—	—	0·89	—	0·02	—	0·29	—	—	—	—
17	—	—	—	0·06	—	—	—	—	—	—	0·02	—
18	—	—	0·05	—	—	—	—	—	—	—	—	—
19	—	—	—	—	—	0·02	—	—	—	0·83	—	—
20	—	—	—	—	0·63	—	—	—	—	0·01	—	—
21	—	—	—	—	2·21	—	—	—	0·57	0·04	—	—
22	—	—	—	—	0·01	3·74	—	1·46	0·28	0·01	—	—
23	—	—	—	—	0·02	0·17	—	—	0·42	—	—	—
24	—	—	0·46	—	0·20	0·02	0·20	—	0·60	—	—	—
25	—	—	—	—	—	0·14	0·21	—	—	—	—	—
26	—	—	—	—	—	0·46	0·86	—	—	—	—	—
27	—	—	—	—	0·02	0·35	0·16	1·16	—	—	—	—
28	—	—	—	—	0·04	0·58	0·05	—	—	—	—	—
29	—	—	—	—	—	0·01	0·01	—	—	—	—	—
30	—	—	0·51	—	0·63	—	—	—	—	—	—	—
31	—	—	—	—	—	—	0·04	—	—	—	—	—
Total ...	—	0·07	1·34	1·95	8·97	6·60	2·81	5·21	2·71	3·33	0·02	—

Total rainfall for year, 33·01 inches.

APPENDIX.

ROTATION EXPERIMENT.

The object of this experiment, started in 1932–33, was to compare the effects on cotton of six treatments, viz., five different rotation crops and fallow, with which it was alternated in two-course rotations. The work has now been brought to a close, after four rotations, and a general summing-up of results is required.

The experiment was laid down in two parts, A and B, each in the form of a randomized block lay-out giving six repetitions of six treatments, with plots of approximately one-tenth of an acre. When A was under rotation crops B carried continuous cotton and *vice versa*; thus in each season records were obtained from cotton following the various treatments. The five rotation crops were:—*cotton*, *sunflower*, *maize*, *tepary bean* and *soya bean*. The fallow was kept free of weeds by cultivation along with the rotation crops.

From 1932–35 the work was carried out by Mr. O. V. S. Heath, who devoted considerable time to it, and from 1936–40 by Mr. D. F. Ruston, who was unable to give it enough time to continue all the original records. Little could be done after the outbreak of war and it has not been possible to analyse completely all the records made during the course of the experiment. The most important results, however, are given in the account that follows.

Effect on the Cotton Crop.

Growth.—Throughout each season the cotton following soya bean has given poorer growth than in the other treatments, and this effect has become rather more marked in successive rotations. Fallow gives the strongest seedlings at about 10 days from germination: growth is then relatively poor till about 4–5 weeks: after this it improves steadily, drawing level with the other treatments at about two months and finally outstripping them all. This course of events, which has been regularly noticeable throughout all eight seasons, is illustrated by the figures for Dry Weights and Height Measurements given in Table I and II.

TABLE I.

DRY WEIGHTS, GMS. PER PLANT, OF COTTON FOLLOWING DIFFERENT TREATMENTS.

Season.	*Age in Days.*	*Fallow.*	*Tepary.*	*Cotton.*	*Sun-flower.*	*Maize.*	*Soya.*	*Sig. Diff. P = ·05.*
34–5	10	·134	·127	·118	·127	·123	·118	·0072
35–6	11	·173	·134	·151	·148	·154	·128	·0214
Mean	10·5	·154	·131	·135	·138	·139	·123	
34–5	39	1·66	2·32	2·46	2·51	2·21	1·80	·539
36–7	28	·80	·84	·87	1·06	·94	·76	·187
37–8	31	·85	·97	·87	1·13	·89	·67	·198
Mean	33	1·10	1·38	1·40	1·57	1·35	1·08	

The initial advantage and later falling-off of the fallow and the generally poor growth after soya bean are clearly seen.

TABLE II.

HEIGHTS IN CMS., COTYLEDONARY NODE TO APICAL BUD, OF COTTON FOLLOWING DIFFERENT TREATMENTS.

Season.	*Age in Days.*	*Fallow.*	*Tepary.*	*Cotton.*	*Sun-flower.*	*Maize.*	*Soya.*	*Sig. Diff. P = ·05*
35–6	28	7·60	9·56	9·86	9·93	8·88	7·43	1·35
36–7	31	9·44	10·31	10·59	11·35	10·44	9·44	1·30
Mean	29·5	8·52	9·94	10·23	10·64	9·66	8·44	
35–6	66	29·4	27·9	27·3	30·9	25·8	24·1	4·16
36–7	63	40·3	38·2	38·6	41·6	37·4	32·4	3·92
Mean	64·5	34·9	33·1	33·0	36·3	31·6	28·3	
35–6	Final	74·4	56·4	54·1	57·8	50·8	49·3	6·4
36–7	do.	93·8	83·2	80·5	88·7	73·5	69·1	7·0
Mean	Final	84·1	69·8	67·3	73·3	62·2	59·2	

Here the earliest stage is not included, but the poor growth of the fallow treatment at four weeks and its very great improvement later are well shown; also the continued poor growth on the soya bean treatment.

For the other treatments there have been variations from season to season, though sunflower has generally given good growth and maize has inclined to be poor.

Flowering and Fruiting.—There have been no differences between treatments in the time at which flowering started, but large differences in the numbers of flowers produced and the percentages set, particularly during the later part of the flowering period.

The poor growth after soya bean has been accompanied by correspondingly poor flowering, but the percentage of bolls to flowers has been normal.

For the other treatments flowering and setting has been much the same during the first few weeks. After this, in all seasons, fallow has steadily drawn ahead, not only giving more flowers but also, particularly in the last few weeks, setting a relatively higher percentage of them. Sunflower always starts well and, with good rains, maintains a later flowering rate above the others and approaching that of fallow: even in such cases, however, the later setting is rather poor. In a dry flowering period it shows no advantage in number of flowers produced and the percentage of setting falls off very much below the others in the second half of the period.

The maize treatment, with slightly poorer flowering generally, has tended to behave in the same manner as sunflower.

These differences in behaviour are illustrated by the figures for two different types of season given in Table III.

TABLE III.

FLOWER AND BOLL PRODUCTION IN TWO TYPES OF SEASON.
SAMPLE 30 PLANTS.

Season.		*Fallow.*	*Tepary.*	*Cotton.*	*Sunflower.*	*Maize.*	*Soya.*
38–9 Wet	Flowers ...	1,521	1,254	1,220	1,527	1,289	876
	Bolls ...	661	516	493	592	494	373
	%	43·4	41·1	40·4	38·8	38·3	42·6
39–40 Dry	Flowers ...	2,141	1,560	1,817	1,590	1,367	1,238
	Bolls ...	866	572	680	481	449	445
	%	40·5	36·7	37·4	30·3	32·8	35·9
Total	Flowers ...	3,662	2,814	3,037	3,117	2,656	2,114
	Bolls ...	1,527	1,088	1,173	1,073	943	818
	%	41·7	38·7	38·6	34·4	35·5	38·7

N.B.—The 1938–39 season had given poorer growth before flowering started.

Yield.—In all eight years treatment effect on yield has been significant. Fallow has given the highest yield every year; soya bean the lowest in all except the first year. There have been changes from year to year in the order of the other treatments, largely determined by the type of season, but tepary bean has been the most steadily good of these.

The yields of all the treatments throughout the experiment are given in Table IV.

TABLE IV.

YIELDS: LB. PER ACRE SEED COTTON, OVER 8 YEARS.

Year.	*Fallow.*	*Tepary.*	*Cotton.*	*Sunflower.*	*Maize.*	*Soya.*	*Sig. Diff. P = ·05*	*Moisture whilst Fruiting.*
33–4	1,046	1,045	884	685	735	776	176	Poor
34–5	856	739	644	664	634	602	147	Moderate
35–6	389	321	272	318	237	157	72	(V. Late)
36–7	1,286	938	728	1,051	758	715	240	Good
37–8	720	555	502	464	460	379	113	Poor
38–9	846	672	615	712	629	480	201	Good
39–40	1,290	871	884	559	615	539	190	Poor
40–1	1,068	859	777	818	861	612	277	Good
								P = ·01
Means	938	750	663	659	616	533	97	127
% C=100	141·5	113·1	100	99·4	92·9	80·4	14·6	19·2

N.B.—The large difference required for significance on the mean yields is due to interaction between treatment and type of season.

It will be seen from the mean yields that fallow leads by a wide margin, being significantly greater than all other treatments at P=·01. Tepary bean is well up, significantly higher than maize and soya bean at P=·05 and only failing by a small margin in significance over cotton and sunflower. The soya bean treatment, as in all other records, has given very poor results, being significantly lower than all but maize.

It is of interest to note in the figures for separate years that sunflower has given its poorest yields, in comparison with other treatments, in seasons of poor moisture during the fruiting period. In wetter seasons it has been relatively good. Thus, putting the combined mean for fallow, tepary and cotton at 100%, sunflower has given 99·4% of this

mean in the three years of " good " moisture, against only 65·7% in the three " poor " years. Maize shows a similar tendency but rather less markedly.

Towards picking time there have been differences, very marked in the later years, in the appearance of the cotton under different treatments. Sunflower closes down and sheds its leaf earliest, followed closely by maize and soya bean ; then comes cotton followed by tepary bean and finally fallow. There is always a wide gap between sunflower and fallow. There is no doubt that these differences in time of closing down affect the yields appreciably. Fallow particularly and tepary bean to a less extent derive advantage from their better finishing.

As would be expected, the early finishing treatments give their crop earlier. This is shown by the figures below, giving, for each treatment, the percentage of its crop picked at about half way through the picking season. The actual dates were the same for all treatments. The figures are means for seven years.

Fallow.	*Tepary.*	*Cotton.*	*Sunflower.*	*Maize.*	*Soya.*	*Sig. Diff. P = ·05.*
47·1	56·1	61·9	63·9	64·3	62·0	5·4

Fallow is significantly later than all others and tepary than the other four.

There has been evidence of progressive changes resulting from the repeated rotations, both in the appearance of the crop in the field and from yields. The fallow treatment appears to have improved and the soya bean to have deteriorated as the experiment progressed. It is impossible to demonstrate this statistically, however, owing to the interaction of treatment and type of season.

Soil Moisture.

Soil moisture determinations have been made in all but the last year, samples being taken in the off season after the harvest of the rotation crops. The deeper samples are the most important, from the point of view of reserve moisture for the cotton to follow : they have also given the greatest differences between treatments. Below are given the mean moisture percentages for 3′, 4′ and 5′ depths, for the seven years from 1933 to 1939.

Fallow.	*Tepary.*	*Cotton.*	*Maize.*	*Sunflower.*	*Soya.*
18·9	17·5	17·5	17·7	15·9	16·2

Sig. Diff. P = ·05 — 1·11 ; P = ·01 — 1·50.

The excessive drying effect of sunflower and soya is very marked, also the good moisture left by fallow. The other treatments, tepary, cotton and maize, are all equal and any differences between them in their effect on the following cotton cannot be attributed to differences in moisture reserves unless lower depths are concerned.

It is impossible to deduce whether reserve moisture is a factor in any of the treatment effects recorded. Sunflower has given very significantly better growth and higher yields of cotton than has soya bean, though their effects on soil moisture are about equal. The same applies to tepary bean and maize respectively. Similarly sunflower has outyielded maize in spite of the latter's big advantage in reserve moisture. Other factors of much greater importance are obviously concerned in these cases.

When the experiment was started it was hoped to carry out soil analyses for plant food determinations, before and after the eight years of rotations, also analyses to give the amounts of plant food removed by all crops. Unfortunately these could not be continued and no evidence on these important points is available.

Practical Aspects.

From a practical point of view the results must be judged largely from the yields of rotation crop and cotton taken together. The mean yields for the whole period are given below in pounds per acre.

	Fallow.	*Tepary.*	*Cotton.*	*Sunflower.*	*Maize.*	*Soya.*
Rotation Crop ...	—	966	565	1,307	1,653	789
Cotton	938	750	663	659	616	533

Prices have not been stable enough for the cash values of the above crops to be worked out with any degree of accuracy. It would appear, however, that fallow and soya bean have given the poorest returns, tepary bean, cotton and sunflower the best, being about equal in value, and maize somewhat lower.

Although this experiment has not demonstrated any loss of crop through growing continuous cotton, there are serious other disadvantages. It makes for labour difficulties, since all the work comes at the same time, and it is undoubtedly an unsound practice in that it breeds up diseases and insect pests to a dangerous extent.

Tepary bean is excellent for small-scale planting, having the great advantage that it can be planted successfully at a later date than the other crops. It is difficult to handle on a large scale if there is rain at harvest, since the ripe grain germinates very readily and also heats rapidly when not quite dry. It is planted thickly and gives some protection against soil erosion. The stover, though small in amount, is good.

Sunflower works in satisfactorily with cotton. It is a little easier to handle at harvest time than tepary, since it can be allowed to dry out more thoroughly in the field. It has the disadvantage of giving a stover that is of no use as cattle food and its rotational effect is bad in dry seasons.

Maize is an extremely easy crop to handle on a large scale and works in well with cotton. It gives a large bulk of stover for cattle food. These advantages would probably make up for its rather lower return in large scale planting.

Residual Effect.

The half of the experiment from which the last cotton crop was taken in the 1939–40 season was planted uniformly to maize this season. Yields of the various rotational treatments were recorded separately with the following results, in lb. per acre.

Tepary.	*Fallow.*	*Cotton.*	*Sunflower.*	*Soya.*	*Maize.*	$P = \cdot 05$
2,690	2,633	2,627	2,538	2,514	2,230	268

Four rotations of maize–cotton have reduced the yield of maize following to a figure significantly lower than all the other treatments.

Summary.

The results are reported of an experiment in which cotton was alternated, in two-year rotation, with fallow, cotton, sunflower, maize, tepary bean and soya bean.

Four complete rotations were carried out on each of two areas, their planting being staggered in time to give cotton over eight successive years.

Cotton following soya bean was regularly poor in growth, flowering and yield. Fallow always gave outstanding results in every way, apart from regularly poor growth between 2–6 weeks, and gave a very significantly higher yield of cotton than all other treatments. Tepary bean was steadily good and gave a mean yield significantly higher than maize and soya bean and approaching significance over cotton and sunflower.

Sunflower gave very poor results in seasons which were dry during the cotton boll-setting period, partly due to the percentage boll-setting being lower than for other treatments in the latter half of the period.

Very marked differences occurred between treatments in the time at which the cotton closed down. Sunflower went off very early, followed closely by maize and soya bean. Fallow remained green much longer, finishing extremely well, and tepary bean was next best. The last two treatments were also latest in opening their crop.

Soil moisture reserves left after harvesting the rotation crops showed regular differences. The mean for seven years, at 3′ to 5′ depths, showed fallow significantly moister than all others. Tepary, cotton and maize were equal and significantly higher than sunflower and soya.

Total returns, of rotation crop and cotton combined, showed the poorest results from fallow and soya bean. Cotton, tepary bean and sunflower were about equal, with maize rather less.

PLANT PATHOLOGY.

PROGRESS REPORT FOR THE SEASON 1939-40.

BY

G. M. WICKENS.

Dr. Wickens being on active service, was unable to prepare his Report on the work of the season 1939–40 in time for its inclusion with the other reports for that season, which were published last year. It is now printed here for the sake of continuity of the record of the plant pathological work done at Barberton up to the end of the 1939–40 season.

Diseases of the Cotton Boll.

The survey method of studying the relationships between cotton boll diseases, insect vector activity, and climatic conditions, which, from results obtained in the season 1938–39, appeared to give promise of yielding much information, was in 1939–40 employed on a larger and more intensive scale. It was, in particular, extended to include plant habit, especially variation in fruiting period, both induced as a result of bollworm attack and inherent in a number of strains and varieties, as a factor in the complex studied. It had been intended that inclusion of this further factor should be additional and complementary to studies in fields of only one variety, in which this further complication did not exist. Unfortunately both of the one-variety fields planted for this purpose failed to give results owing to poor plant growth, and, presumably in consequence, an almost entire lack of vector populations. Hence useful data were obtained only from fields in which the additional complication of variation in plant habit was present. A large mass of data has been obtained, but satisfactory interpretation of much of it must await further analysis made in the light of greater knowledge of feeding habits of all stages of the vectors, of transmission and development of internal boll disease, and of infection by and development of bacterial boll disease, all in relation to boll development. It is to "synthetic" methods of direct experiment, rather than "analytical" methods of survey, that attention should now be paid. Nevertheless the survey method has served a most useful purpose in defining the boll disease problems that would most repay intensive study, and in indicating those factors that have a marked controlling effect on the incidence of boll diseases.

General Results.

As in the previous season, stainer and pentatomid bug populations, in well-grown fields, were sufficient in size and in the earliness in time

of immigration in relation to putting on of crop to cause puncturing in an appreciable proportion of the bolls. But again the incidence of internal boll disease was relatively slight, indicating the probability that the immigrant bug populations contained only a very small proportion of actual vectors of internal boll disease. *Dysdercus nigrofasciatus* was again greatly the predominant stainer species, and *Nezara* the predominant pentatomid genus, with pentatomids few relative to stainers.

Bacterial boll rots were of the same types as recorded in the previous season, viz. :—

(*a*) Direct attack of the uninjured boll wall tissues, the lesions advancing through the wall and the bacteria eventually reaching and attacking the lint. Usually such lesions were at the extreme base of the boll.

(*b*) Entrance through a channel left at the tip of the boll by incompletely joined carpels.

(*c*) Entrance *via* bug punctures, with boll wall lesions, if any, spreading from within outwards. Relatively rare.

Type (*b*) was much less common than in the previous season.

Boll rots caused by fungi capable of attacking and penetrating the uninjured boll wall were again very rare, although anthracnose was occasionally recorded.

The main climatic feature of the season was the lack of any effective rain during February and early March. The result of this drought, which needs to be borne in mind in considering the more detailed results about to be presented, was a beneficial effect on growth and yield of bollworm-infested plants as compared with uninfested plants, and on late as compared with early varieties.

The Effect of Variation of Fruiting Period induced by Bollworm Infestation, on the Incidence of Direct Bug Feeding Injury and Internal Boll Disease.—The relationships between fruiting period on the one hand and the incidence of direct bug feeding injury and of internal boll disease on the other are clearly illustrated in the following data. The data were obtained from examination of every lock of every split boll on each of 10 plants of strain 5143, of which five plants had produced a normal crop and five an exceptionally late crop as a result of an early and heavy artificially applied bollworm infestation. The methods employed were as follow.

The 10 plants were situated five in each of two rows of variety 5143. The two rows were situated one in each of two plots, of which one had been heavily artificially infested with bollworm and one had not been infested. These rows had been " tagged " at approximately weekly

intervals, each flower and boll developed since the previous occasion being "tagged" with coloured wools to indicate date of formation. When all bolls had split, five plants from each row, selected as showing the characteristic effects of heavy bollworm attack and no bollworm attack respectively, were removed and brought to the laboratory. Each plant being treated separately, the bolls were removed and collected into age groups, and all locks not directly affected by bollworm attack were graded according to previously prepared standards for extent of direct bug feeding injury and for extent of internal boll disease. By a system of scoring for the several grades the following figures were obtained for extent of injury as per cent. of lint damaged (Table I). The estimate for extent of injury by internal boll disease was obtained by subtracting from the score for direct injury + internal boll disease the score for direct injury alone. (It must be emphasised that these estimates are of value for comparative purposes only, having no absolute significance.)

TABLE I.

BOLLWORM INFESTATION.	*Boll Formation Dates.*	*No. of Locks.*	*% of locks affected by*		*Estimated % of lint damaged by*		*Weight of locks in grms.*	*Mean weight seed cotton per lock in grms.*
			Direct injury alone.	*Internal boll disease with or without direct injury.*	*Direct injury alone.*	*Internal boll disease apart from direct injury.*		
HEAVY (Totals of 5 Plants).	Up to 17/1	36	8·5	30·6	3·1	11·7	27·5	0·76
	18/1 to 5/2	170	31·8	19·4	13·1	4·4	163·0	0·96
	6/2 to 20/2	358	31·3	23·7	9·1	7·1	379·0	1·06
	21/2 to 5/3	216	56·9	37·0	24·2	16·0	187·0	0·87
	6/3 to 20/3	107	80·4	25·2	56·1	9·3	56·0	0·52
TOTALS	All dates	887	42·6	26·6	18·9	9·2	812·5	0·92
NIL (Totals of 5 Plants).	Up to 17/1	59	13·6	8·5	5·1	3·7	66·0	1·12
	18/1 to 5/2	259	23·9	12·4	12·1	6·9	223·5	0·86
	6/2 to 20/2	228	15·8	3·1	8·0	1·5	138·5	0·61
	21/2 to 5/3	8	0·0	0·0	0·0	0·0	—	—
	6/3 to 20/3	0	—	—	—	—	—	—
TOTALS	All dates	554	19·1	8·0	9·5	4·2	435·0	0·79

In this table the effect of the artificially applied bollworm infestation, in causing the loss of part of the normal early crop and a compensatory development of a later crop, is clearly seen.

In each class of plants, bug feeding activity, as measured by extent of direct bug feeding injury, was much the same in bolls formed up to 20th February, the figures being, for heavy bollworm infested plants 9·9% and for control plants 9·6%. In later formed bolls, formed almost exclusively on the heavy bollworm infested group, bug feeding

activity was much greater. The respective figures for percentages of locks affected by direct injury are approximately 30% and 19% ; thus in the bollworm infested group of plants more bolls (formed up to 20th February) were affected by direct bug feeding injury than were affected in the control plants, but the intensity of damage in the affected bolls was correspondingly less. Many tentative explanations might be offered for this more extensive but less intensive bug feeding injury in the one group than in the other. This is, however, one of the many observations made which require, for correct interpretation, more knowledge of the feeding habits of stainers. This observation does not in any case affect the main result, which clearly is that the effect of the bollworm infestation has been to push the crop, as it were, on into a period of increasing bug feeding activity.

Disallowing the figures for bolls formed up to 17th January (legitimately since the samples are very small), the expected rise in extent of internal boll disease in progressively later-formed bolls is seen, with a notable exception in the latest-formed groups. The latest-formed bolls almost without exception failed to reach full maturity, yielding at best weak and immature lint and splitting prematurely. Such bolls appear, probably as a result of their abnormal physiology, to be less liable to shew the characteristic effects of internal boll disease.

Confirmatory and more extended evidence on the effect of a bollworm infestation in causing greater crop loss through direct bug feeding injury and internal boll disease, was obtained by examinations of dated bolls on sample plants in plots subjected to various artificial bollworm infestation treatments, the sample plants being withdrawn at successive intervals of time. Weekly records of stainer (Vth instar and adult) and pentatomid populations were made in these plots. The mass of data obtained has not been fully analysed—such analysis indeed, would scarcely be profitable until the feeding habits of the different instars of stainers are more fully known. In Table II are summarised figures illustrating the extent of puncturing of locks on sample plants subjected to heavy, light, and no artificial bollworm infestation, at three intervals of time, the locks being classed into groups according to date of formation.

On 7th March and 14th March the number of adult stainers in all plots was low, being only one per 10 plants approximately. Young broods of the F_1 generation, mostly of I and II instars, were common ; a very few broods of III and one only of IV were also seen. The bolls examined on the first and second occasions (6th March and 18th March) had therefore been exposed to the feeding of a small immigrant adult

population of stainers (pentatomid numbers were throughout insignificant) and a relatively large, but recent and very young, F_1 generation. By 14th March almost all of the bolls on control (*i.e.*, no bollworm infestation) plants were already more than four weeks old, and therefore probably past the stage at which stainer feeding would result in more than insignificant local destruction of developing lint. On the other hand, a considerable part of the crop on the heavily bollworm infested plants was of younger age.

TABLE II.

Dates of Examination.	*Boll Formation Dates.*	*Ages of Bolls (days).*	*Degree of Bollworm Infestation.*					
			HEAVY (2 plants each examination).		*LIGHT (2 plants each examination).*		*NIL (4 plants each examination).*	
			No. of Locks.	*% Punctured.*	*No. of Locks.*	*% Punctured.*	*No. of Locks.*	*% Punctured.*
	Up to 17/1	49 to 55+	9	100	17	82	43	44
	18/1 to 5/2	30 to 48	72	39	86	33	193	13
(1st)	6/2 to 20/2	15 to 29	92	16	74	5	189	10
6/3	21/2 to 5/3	1 to 14	65	0	44	2	73	0
	6/3 to 20/3							
	TOTALS	All Ages	238	22	221	21	498	12
	Up to 17/1	61 to 67+	(4)		(16)		(50)	
	18/1 to 5/2	42 to 60	23	17	98	29	260	30
(2nd)	6/2 to 20/2	27 to 41	96	19	93	32	268	22
18/3	21/2 to 5/3	13 to 26	97	19	46	30	8	25
	6/3 to 20/3							
	TOTALS	All Ages	216	19	237	31	536	26
	Up to 17/1	75 to 81+			(20)		(45)	
	18/1 to 5/2	56 to 74	(4)		(93)		(252)	
(3rd)	6/2 to 20/2	41 to 55	62	68	122	45	135	21
2/4	21/2 to 5/3	27 to 40	104	83	76	49		
	6/3 to 20/3	13 to 26	29	76				
	TOTALS	All Ages	195	77	198	46	135	21

Figures in brackets indicate numbers of locks of bolls almost all of which had split. No relative % of punctured locks is given owing to impossibility of accurately estimating puncturing in split bolls. Bracketed figures are not included in the totals.

From 14th March onwards the numbers of Vth instar and adult stainers rose rapidly, reaching a figure of nearly 14 per 10 plants on 28th March and maintaining thereafter a high level. Between the second and third sampling occasions (18th March and 2nd April), therefore, the bolls were subjected to a further 15 days' exposure to the feeding of stainers, of which rapidly increasing numbers of Vth instars and adults were present. From 18th March onwards also, bolls in the control (not bollworm infested) plots were rapidly splitting,

and the plants were "closing down." Presumably in consequence, there was at this time observed the beginnings of a tendency for adult stainers particularly to concentrate in the more leafy plots—that is the bollworm infested plots. The relatively late-formed bolls of the heavily bollworm infested plants, and to a lesser extent those of the lightly bollworm infested plants, therefore suffered relatively great exposure to the feeding activity of stainers, with the results as shown in Tables I and II.

A feature worthy of note in Table II is the evidence of only very slight puncturing in bolls up to a fortnight old.

The main results of this survey may be summed up as follows :—

(*a*) Populations of Vth instar and adult stainers remained small in plots of normal plants until almost all of the bolls contributing to final yield were more than four weeks of age. Most of the F_1 generation appeared only shortly before this time, and could have had relatively small effect on the developing bolls.

(*b*) The effect of bollworm infestation was to destroy part of the normal crop and cause the compensatory (in this instance probably more than compensatory) development of a later crop, this effect being greater with heavy than with light bollworm infestation.

(*c*) In consequence of this, a number of the bolls giving rise to final yield in bollworm infested parts of the field were exposed to greater bug feeding activity than that to which any of the bolls on normal plants were exposed.

(*d*) These bolls were also exposed to large numbers of Vth instar and adult stainers at a relatively early stage in their development.

(*e*) While therefore all of the crop on normal plants escaped appreciable injury from bug feeding, the later portions of the crop on bollworm infested plants suffered appreciably from this cause.

(*f*) The effect of bollworm infestation was therefore to lay the crop more open to damage arising from bug feeding, the effect being greater where the bollworm infestation was heavier.

(*g*) The incidence of internal boll disease was slight.

(*h*) In conformity with expectation, incidence of internal boll disease was higher in progressively later formed bolls, except that in the last formed, in both normal and in heavily bollworm infested plants, incidence was less than expected. A likely cause of this lies in the abnormal physiology of such bolls.

The Differential Behaviour of a number of Strains and Varieties, varying in Growth, Habit and in Period over which Crop is Produced, in relation to Bug Populations, Direct Bug Feeding Injury, and Internal Boll Disease.—Methods adopted in this survey were as follows :—

(*a*) *The plant material :* Eight strains and varieties were selected for this survey :—

9363	(a strain of Cambodia).
H.19	(from a Cambodia × U.4 backcross).
BP.50/3	(a strain from Uganda).
Z.14	strains of U.4.
0268	
6250	
5143	
929	

Twenty-two randomised blocks, each of eight rows (one row of each variety), were planted for the purposes of this survey. Twelve of these, planted on 24th October, 1939, on granite soil, grew poorly and presumably in consequence there was an almost entire absence of inhabiting internal boll disease vectors. attention was therefore focused on six of the better grown blocks planted later, on 30th November, 1939, on loam soil.

Shortly before the first flowering, four plants in each of the 48 rows (*i.e.*, 24 plants of each variety), were marked as experimental plants. It had originally been intended to take the experimental plants entirely at random, with the restriction that the plants selected be not adjacent to gaps. In effect, owing to poor germination, and a further necessary restriction that " topped " plants be avoided, the element of chance had little scope in the selection and the condition that gaps be avoided could not always be fulfilled.

From the first week in February (when flowering started) onwards, as nearly as possible twice weekly, date taggings were made of all flowers and young bolls formed since the previous tagging occasion, on the 192 experimental plants. As the bolls split they were collected, with date tags attached, into bags, one bag for each plant, the produce of each plant being separately stored to await later examination.

(*b*) *Bug Populations :* Periodical inspections during February and March indicated that during that period stainers and pentatomids were present in only very small numbers. From 3rd April onwards weekly counts were made of the total stainer (Vth instar and adult) and pentatomid bug populations in every row.

(*c*) *Other Records :* The stand, yield of seed cotton at each of three pickings on 9th May, 3rd June and 27th June, and occasional split boll counts, were recorded for every row, the four experimental plants in each row being excluded.

(*d*) *Laboratory Examination:* The yield of each individual experimental plant was examined in the laboratory as follows :— First, all the date tags were removed, classified into groups, and the number of bolls in each age group thus recorded. The locks of each plant were then removed one by one and classified into the following groups :—

A directly affected by bollworm attack.
B immature locks, not normally picked.
C clean locks showing no attack or injury.
D locks showing symptoms of direct injury as a result of bug feeding.
E locks showing the symptoms of internal boll disease with or without symptoms of direct injury.
F locks showing the symptoms of external boll disease (*i.e.*, bacterial rots, Anthracnose).

The number of locks in each group was then recorded ; also the weight of each group.

From the seed cotton in each group of locks all unsound lint was removed and the remainder ginned, the weight of clean lint yielded by each group being then recorded. By simple calculation from the weight of lint yielded by a known number of locks of group C, the loss of crop resulting from each of the causes enumerated above is readily estimated.

By these laboratory operations the following data have been obtained for each of the 192 experimental plants (24 plants of each of the eight varieties) :—

(1) The fruiting period.
(2) The proportion of locks failing to reach maturity.
(3) Of the maturing or potentially maturing locks, less the very few affected by direct bollworm attack—
  (*a*) percentage of sound clean locks and weight of clean lint obtained therefrom ;
  (*b*) percentage of locks directly injured by bug feeding but without symptoms of secondary attack by micro-organisms ;
  (*c*) the extent of this direct injury as deduced from weight of clean lint obtained as compared with estimated weight that would have been obtained but for such injury ;
  (*d*) percentage of locks affected by internal boll disease in addition to direct injury, with similar estimate of extent of damage caused by internal boll disease ;
  (*e*) percentage of locks affected by external boll disease with similar estimate of extent of damage.

The main results of this survey are as follows :—

Differential Behaviour of Varieties in Relationships between Crop Production and Vector Population.—In Figure I (p. 52) crop production by and vector* populations in six of the eight varieties are graphically represented. Z.14 and 6250 are eliminated, the former because of extremely erratic figures for vector populations (probably due to the very thin stand and small numbers of plants from which the data were obtained) and the latter because both in rate of crop production and in vector populations it was very similar to 5143. On each " curve " for rate of crop production two points, with the variety designation alongside, are indicated. The higher point on each " curve " indicates for each variety the number of bolls retained by the plant that matured sufficiently to give " pickable " cotton, or that were judged capable of having thus matured but for the incidence of disease or injury. In each variety the great majority of bolls formed before the relevant dates (the abscissæ of the points indicated) went to make up final yields, while only a small proportion of those formed after those dates developed to maturity. The lower of the two points indicates for each variety the percentage of the total crop that was picked at the first picking on 9th May.

Considering the vector " curves " in relation to boll production " curves," there are three striking features that can be readily related to crop production variations between varieties.

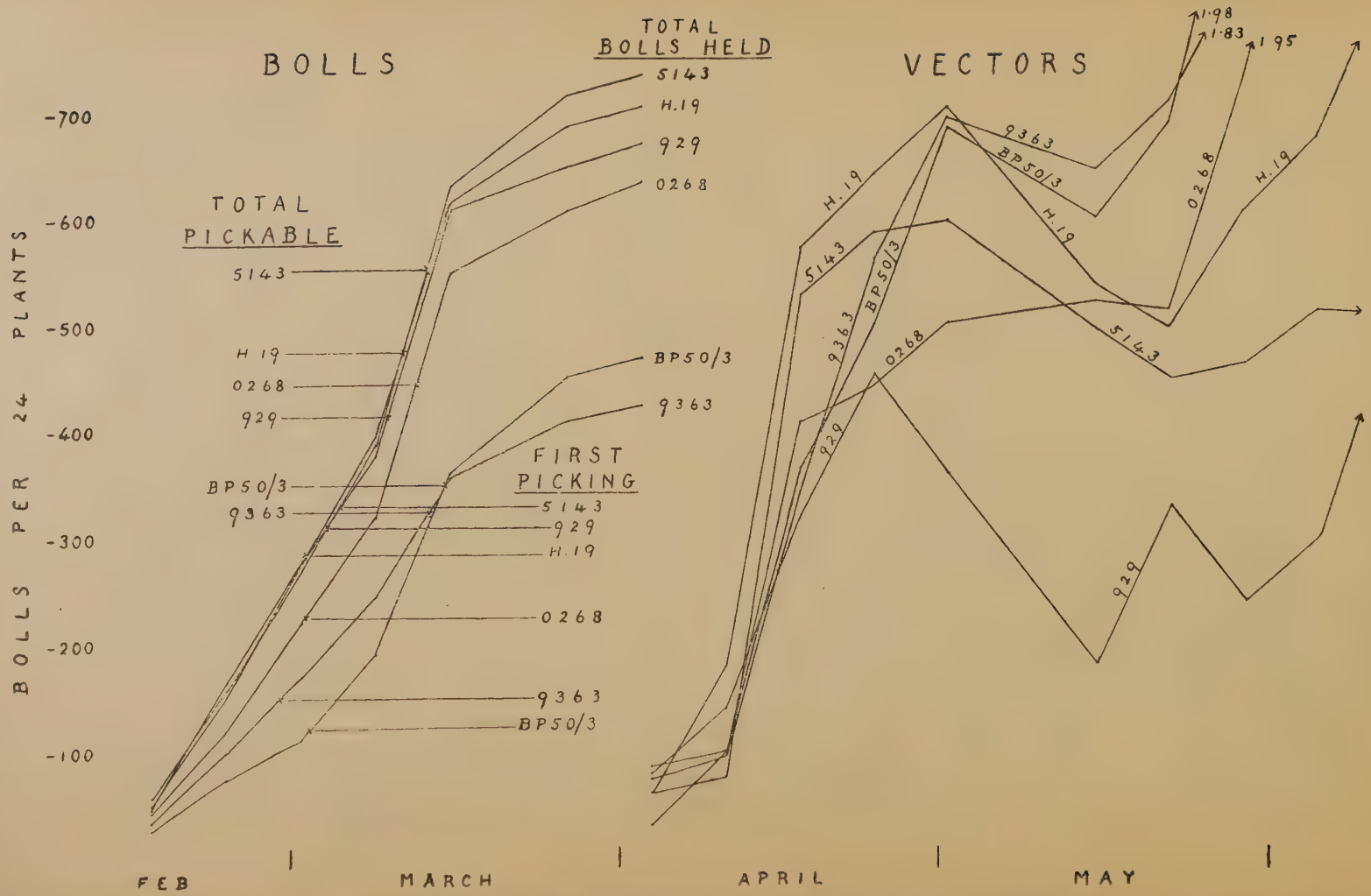
Firstly, the early falling off of vector populations in 929 from 24th April onwards. During the period of this rapid fall, from 24th April to 15th May, the bolls in this variety were splitting rapidly and the variety was " closing down " with early leaf fall. 75% of the crop of this variety was picked on 9th May.

Secondly, in the other varieties there was a more or less rapid rise in populations up to 1st May followed by a slackening in the rise or an actual decrease which was a shorter or longer prelude to a second rise. In BP.50 and 9363 the period of decrease was short and the following rise very rapid. In H.19 and 5143 the decrease was greater and lasted longer followed by a fairly rapid rise in H.19 and only a slight rise in 5143. In 0268 the population was constant in size from 1st May to 22nd May, followed thereafter by a rapid rise.

Thirdly, the early rise in vector populations, if we except the aberrant 929, was more rapid in the rapid fruiting varieties 5143 and H.19 than in varieties 0268, 9363 and BP.50/3 which put on bolls relatively slowly.

The data are in conformity with the hypothesis that a variety on

* The term " vector " is used as a brief term embracing Vth instar and adult stainers and pentatomids.



"Fig. 1. Setting dates of Bolls retained and Vector Populations of 6 Varieties."

" closing down " becomes relatively less attractive to the vectors, which tend to move away from such varieties and to concentrate in those that are still leafy and still carry green developing bolls. The data also conform in general to the hypothesis that vector populations tended to maintain a constant ratio to numbers of green bolls present. Rather late in the season, on 5th June (just before the second picking was made), green boll counts were made as well as vector counts. The figures obtained were as follow. (The figures are total vectors and total green bolls per six rows of each variety, and per eight rows in each block.)

Variety.	*Vectors.*	*Green Bolls.*	*Block.*	*Vectors.*	*Green Bolls*
Z.14	163	172	I	1,106	1,375
929	196	85	II	983	762
0268	692	651	III	550	500
H.19	389	488	IV	659	552
6250	429	602	V	281	460
5143	422	469	VI	208	531
9363	634	460			
BP.50/3	862	1,253			

Analysis of the data by co-variance showed differences between the varieties in green bolls and in vector populations to be very highly significant. The two variables are positively correlated. When " corrected " for green boll numbers the very high significance of difference between varieties in vector populations vanishes. Undoubtedly on this occasion the greater leafiness of the varieties and blocks carrying the largest numbers of green bolls was a factor in their carrying larger populations. Whether, this factor being absent, the greater concentration of vectors in varieties carrying larger numbers of green bolls as found on 17th April (929 being excepted) is significant or not, has not been established. To sum up : the evidence indicates that distribution of vectors between the varieties was at random, except for a tendency for greater concentrations in varieties carrying relatively large numbers of green bolls, the effect of this tendency being to equalise over all varieties the stainer/green boll ratio. It appears probable that, on analysis, differences between varieties in stainer/boll ratio would be found on any single occasion to be quite insignificant.

Given that stainer/green boll ratios are equal in all varieties, then percentage of crop loss occasioned by stainer feeding activity in any one variety will be governed by the following factors :—

(*a*) The rate of maturation of individual bolls.

(*b*) The relation of formation of bolls retained on the plant to time.

(*c*) The proportion of bolls, of those retained on the plant, capable of contributing to final yield.

(*d*) The inherent susceptibility of the developing lint of the particular variety to direct injury arising from bug feeding and to micro-organisms that may be introduced thereby.

The extent to which these various factors may have contributed to the observed variations between varieties of incidence of direct bug feeding injury and of internal boll disease, is discussed in the following section.

Differential incidence between Varieties of Direct Injury arising from Bug Feeding and of Internal Boll Disease.—In Table III are summarised data obtained from examinations as described above of total crop produced by 24 plants of each variety excepting Z.14.

TABLE III.

Variety.	*No. of locks formed and retained by the plants.*	*No. of locks matured or judged capable of reaching maturity.*	*% of locks matured.*	*% of locks affected by direct injury and/or internal boll disease. (A)*	*Estimated yield of lint but for incidence of direct injury and I.B.D.*	*% loss of lint as result of direct injury and internal boll disease. (B)*	*A/B.*
929	3,272	2,036	62	9·9	499 grms.	4·6	2·2
6250	3,292	2,116	64	14·6	709 „	7·2	2·0
H.19	3,577	2,409	67	16·5	759 „	8·7	1·9
0268	3,174	2,235	70	18·1	713 „	6·7	2·7
BP.50/3	2,655	1,906	72	21·3	586 „	10·2	2·1
9363	2,150	1,631	76	21·7	614 „	11·1	2·0
5143	3,391	2,505	74	22·6	796 „	11·8	1·9
TOTALS	21,511	14,838			4,676 „		

In this instance the method employed does not permit a proper estimate of damage caused by internal boll disease as distinct from and additive to that caused by direct bug feeding injury. The data obtained do however indicate, firstly, that loss caused by internal boll disease was considerably less than that caused by direct injury, and secondly, that between varieties the ratio between percentage loss of crop caused by direct bug feeding injury alone to percentage loss of crop caused by internal boll disease, with or without accompanying direct injury, did not vary appreciably. It therefore appears reasonable, in comparing varieties in their reaction to stainer populations, to take the figure for percentage loss of crop caused by direct injury and internal boll disease together as a comparative index of the incidence of either of the components, as well as an estimate of the absolute incidence of both together.

The mean maturation period of bolls forming the major part of the crop in each variety can be graphically estimated, and it is found that the maximum variation is of the order of six days, varying from about 66 days in 929 to about 72 days in 9363. If, therefore, between the varieties there exists concomitant variation in length of period of boll growth over which susceptibility is high, it would appear that such variation

would hardly be large enough to cause appreciable variation in extent of damage arising from bug feeding.

It has already been shown that, in a given field, relatively late plants are subject to greater damage from bug feeding activity than early plants. It is therefore to be expected that, in this instance, relatively late varieties (that is, varieties that are late either because of a relatively late putting on of bolls—*e.g.*, BP.50/3—or because of a greater inherent ability to develop to maturity relatively late-formed bolls—*e.g.*, 5143) would suffer a greater incidence of such damage than relatively early varieties.

The data of Table III indicate a very marked correlation between " lateness " and incidence of direct bug feeding injury and internal boll disease. The amount of damage from these causes in any variety has therefore evidently been largely governed by the relation between the period over which bolls giving yield were developed and stainer activity over the period of their development.

The ratio A/B in Table III gives a comparative estimate, for each variety, of the extent of damage in affected locks. This ratio is seen to be remarkably constant : 0268 is the one appreciable aberration, possibly indicating a measure of inherent resistance.

The survey has therefore failed, with this one possible exception of 0268, to indicate any inherent variation in resistance to direct bug feeding injury or to infection by micro-organisms introduced thereby.

Differences between strains and varieties in incidence of direct bug feeding injury and internal boll disease thus appear to be in conformity with the hypothesis that incidence is largely controlled by the measure of escape of the developing bolls from bug feeding, this measure of escape being greater the earlier the fruiting habit of the plant. There has not appeared any clear evidence of any marked variation in inherent susceptibility or resistance in any of the strains or varieties studied.

Discussion of the Relationship between Plant Fruiting Habit and Incidence of Crop loss arising from Bug Feeding.—The major result of these surveys has been to show that factors tending to lengthen, on the side of lateness, the period over which the crop is produced, have the effect of increasing the damage resulting from bug feeding.

Means of control of such damage therefore lie in the development of varieties capable of forming as large a crop over as short a period as possible, and in control of agencies such as bollworm attack which tend to prolong the period of crop production.

The results also bring out a factor in disease control that is rarely if ever stressed in the literature—uniformity in crop production among the plants yielding the crop. In a cotton field, any factor tending to

extend the crop production period on the side of lateness (*e.g.*, a bollworm attack affecting some plants more than others) will be a factor tending to increase the incidence of direct bug feeding injury and internal boll disease. This is probably but one instance illustrating a general principle:—Any factor tending to prolong the period of crop production, by delaying it in a proportion of the plant population, will tend to increase the incidence of disease in that crop.

The Incidence of External Boll Disease in Plants subjected to varying degrees of Bollworm Infestation, and in relation to Rainfall.—Concurrently with the recording of direct bug feeding injury and internal boll disease in bolls of known time of formation carried on plants that had been subjected to varying degrees of bollworm infestation, data relative to the incidence of bacterial boll disease were obtained in a similar manner.

The data here given refer to bacterial boll rots of two types in which (*a*) access to the lint was gained by penetration of the bacteria through the boll wall, almost invariably at the extreme base of the boll; and (*b*) access was through a channel at the tip of the boll resulting from incomplete union of the carpels. The latter type was relatively very uncommon.

TABLE IV.

Boll Formation Dates.	*Rainfall over 4 weeks from earliest formation date.*	*1st Examination (6/3).*				*2nd Examination (18/3).*				*3rd Examination (2/4).*			
		No. of locks.	*Locks with E.B.D.*		*Ages of locks in days.*	*No. of locks.*	*Locks with E.B.D.*		*Ages of locks in days.*	*No. of locks.*	*Locks with E.B.D.*		*Ages of locks in days.*
			No.	%			*No.*	%			*No.*	%	
	in.												
12/1 to 17/1	4·82	109	42	38·5	49 to 54	121	46	38·0	61 to 66	—	—	—	—
18/1 to 26/1	3·76	193	31	16·1	40 to 48	169	24	14·2	52 to 60	207	36	17·4	67 to 75
27/1 to 5/2	1·58	383	20	5·2	30 to 39	352	19	5·4	42 to 51	314	35	11·1	57 to 66
6/2 to 12/2	0·98	358	5	1·4	23 to 29	276	18	6·5	35 to 41	224	20	8·9	50 to 56
13/2 to 20/2	1·39	222	5	2·3	15 to 22	305	12	3·9	27 to 34	313	37	11·8	42 to 49
21/2 to 27/2	*2·94	111	2	1·8	8 to 14	154	2	1·3	20 to 26	152	16	10·5	35 to 41
28/2 to 5/3	†4·10	150	0	0·0	1 to 7	103	1	1·0	13 to 19	133	0	0·0	28 to 34
TOTALS		1,526	105	6·9		1,480	122	8·2		1,343	144	10·7	

* 1·96 inches of this total fell between 15th and 19th March.
† Most of this rainfall fell in the latter half of the period.

In Table IV are presented summarised data, showing on each of three successive occasions the percentage of locks of various date-of-formation groups to which bacteria, agents of external boll disease, had gained access. (Data for individual samples of less than 100 locks are omitted.) The rainfall in inches that fell during the first three to four weeks of development of the bolls of each date group is also given.

TABLE V.

Boll formation Dates.	*No. of Locks.*	*Locks affected by External Boll Disease.*		*Estimated % of Lint destroyed by External Boll Disease.*	*B/A.*
		No.	% (*A*).	(*B*).	
Up to 17/1	95	26	27·4	17·8	0·65
18/1 to 5/2	429	97	22·6	16·8	0·74
6/2 to 20/2	586	87	14·8	8·3	0·56
21/2 to 5/3	224	20	8·9	5·1	0·57
6/3 to 20/3	107	0	0·0	0·0	—
TOTALS	1,441	230	16·0	10·3	0·64

In Table V are summarised data obtained from examinations of bolls formed by 10 plants, of which five had been heavily artificially infested by bollworm and five had not been infested. In this Table the figures of column B/A indicate, for each date-of-formation group, the relative extent of damage to the affected locks.

The data have not been fully analysed, but it is clear that the earliest bolls have suffered most from attack by the organisms of external boll disease—not only was the proportion of bolls affected higher in the earlier-formed groups, but also the extent of damage in affected locks was higher. In consequence, the crop on the heavily bollworm-infested and late-fruiting plants suffered less from this cause than that on the non-infested earlier plants, the figures for percentage of locks attacked and estimated loss of crop resulting being respectively 12·3% and 8·6% for the heavily infested and 21·8% and 13·1% for the control non-infested plants.

The data are not adequate to give precise information on the influence of climatic factors on the incidence of external boll disease, but it would appear that rainfall and humidity during the period of rapid boll growth are probably of considerable importance. With the exception of the very late settings, incidence of bacterial boll disease was positively correlated with rainfall during the formative periods of the bolls.

It is worthy of note that, in this instance, some factor has negatived the operation of the general principle that later formed crops are more liable to infection owing to an increase in local population of the pathogen. Among bolls formed up to 20th February, climatic conditions immediately surrounding progressively later formed bolls becoming progressively less favourable to the inception of infections and to the extension of resulting lesions, probably comprised at least a large part of this factor.

This factor might also in part account for the still lower incidence of external boll disease in bolls formed after 20th February, in spite of the breaking of the drought, for these late settings passed their early stages of development in relatively exposed situations, owing to considerable leaf fall having then occurred. Also, it seems reasonable to suggest that after an initial increase in local population of the pathogen, the drought caused a reduction in numbers as a result of desiccation of leaf, stem, and boll lesions.

These factors might account for the low incidence of external boll disease in the abnormally late settings, in spite of the breaking of the drought during their early development.

The Differential Incidence of External Boll Disease in a number of Strains and Varieties.—The incidence of external boll disease in the seven strains and varieties 9363, H.19, BP.50/3, 0268, 6250, 5143 and 929, was determined in 24 plants of each variety by the methods previously outlined. The data obtained, which are given in Table VI, clearly indicate between the strains and varieties a marked variation in incidence of bacterial boll disease.

TABLE VI.

Variety.	*No. of Locks matured or judged capable of reaching maturity.*	*% of Locks affected by External Boll Disease. (A).*	*Estimated yield of lint but for incidence of External Boll Disease. (in grms.)*	*% Loss of lint caused by External Boll Disease. (B.)*	*B/A.*
H.19	2,409	4·3	710	2·5	·58
Z.14	1,664	5·9	479	3·6	·61
0268	2,235	10·1	702	5·2	·51
6250	2,116	10·3	690	4·7	·46
5143	2,505	15·2	791	11·3	·74
BP.50/3	1,906	16·3	563	6·5	·40
9363	1,631	17·7	614	11·1	·63
929	2,036	30·9	628	24·2	·78
TOTALS	14,838		5,177		

There were appreciable differences between some of the varieties in the period over which bolls giving yield were formed, and this variation may have contributed to the observed variations in incidence of external boll disease. Unfortunately no data had been obtained from this particular planting on the incidence of external boll disease in bolls of the individual date-of-formation groups, and the extent to which variation in incidence of external boll disease may have been brought about by variation in period of crop production is unknown.

Two of the varieties, 6250 and 929, were, however, so closely similar

in respect of the period over which their crops were formed that there can be no doubt that under the conditions of the experiment 929 was much the more susceptible.

The method of recording has been such that it is not possible to determine the relative influence of variable susceptibility to occurrence of infections, and variable susceptibility to extension of lesions developing therefrom, as factors giving rise to variable degrees of damage resulting from bacterial boll disease in the strains and varieties. The latter was, however, an important factor. Figures in the column B/A are estimates, for each strain and variety, of the extent of damage in affected locks, and reflect the general observation that, in particular, boll wall lesions in 5143 and 929 rapidly penetrated to the developing lint causing considerable destruction, while on the other hand boll wall lesions in BP.50/3 and 6250 penetrated relatively slowly, the bacteria reaching the lint at a later and more resistant stage of the latter's development.

The survey has thus failed to establish clearly the existence, in these strains and varieties, of variation in inherent susceptibility to bacterial boll disease, except that under the conditions of the experiment 929 was more susceptible than 6250. 929, however, grew poorly—in particular the boll walls were abnormally thin, and in the previous season there was recorded an unexpectedly high incidence of bacterial boll disease (rainfall being very light) in a crop which, being enfeebled by drought, was characterised by early closing down and abnormally thin boll walls. It is therefore possible that in this instance the high incidence of the disease in 929 was due, not to a greater inherent susceptibility, but rather to the environment being less favourable to this strain than to the others.

Nevertheless there are indications of a possibility, worthy of further investigation, of a measure of resistance in at least some of the strains as compared with 5143—particularly 6250, H.19, and BP.50/3.

Discussion of Factors affecting Incidence of External Boll Disease.—During seasons 1938–39 and 1939–40, external boll diseases at the Cotton Experiment Station, Barberton, were of two types, to the virtual exclusion of all others :—

(*a*) Bacterial attack of the uninjured boll wall tissues, the lesions advancing through the wall and the bacteria eventually reaching and attacking the lint.

(*b*) Penetration of bacteria to the lint *via* a channel left at the tip of the boll by incompletely joined carpels.

Type (*b*) was relatively uncommon, the malformation apparently occurring only in bolls passing their early stages of development

during periods of exceptionally heavy rainfall. Some strains appear to be more prone to such malformation than others.

In type (*a*), the site of infection was almost always at the extreme base of the boll, although lesions elsewhere on the boll surface have occasionally been seen. The reason for this is unknown, but there are two probabilities worthy of note. It may be due to a particular susceptibility to infection of certain tissues in this region, or to the fact that at flower drop and for a day or two afterwards the calyx forms a cup round the base of the very young boll, in which droplets of water, possibly carrying pathogenic bacteria, would readily lodge. When, after a day or two, the young boll has grown so as to cause the calyx to be closely adpressed to the base of the boll, the bacteria would be held in a perfect inoculation chamber.

In early planted crops of normal growth, in both seasons, damage from external boll disease of type (*a*) was greatest in the early formed bolls. In both cases, also, the early formed bolls were subject, during the early part of their development, to conditions of higher rainfall than those formed later. These data are therefore in conformity with expectation, for rainfall is to be expected largely to govern incidence in a number of ways—directly, by spread of contamination by rain-splash, movement of bacteria in surface films of water, etc., and indirectly, by influencing atmospheric humidity and turgor of the host cells.

There is, however, evidence that other factors have exerted a notable and even overriding influence. The exceptionally late formed bolls on bollworm infested plants—the exceptionally late settings in Tables IV and V—in spite of having been subjected to heavier rainfall during early development than some of the bolls formed earlier, were less affected by external boll disease. It is suggested that their development in relatively exposed situations, and the reduction in local population of the pathogen brought about by the drought, contributed here to the increased rainfall not having the expected effect. There has also been indication that crops enfeebled by drought conditions suffer considerably from external boll disease in spite of low rainfall. Plants thus enfeebled tend to have thin boll walls, and there are grounds for the opinion that thickness of boll wall, variable through inherent tendencies of difference strains and varieties and also through conditions affecting general vigour of the plant, may be an important factor governing extent of loss from this cause.

The Causes of "Bad Opening."—During the course of selection work season after season, certain strains have gained the reputation of being "bad openers"—*i.e.*, they regularly exhibit a tendency for failure of their carpels to reflex fully on splitting. While no direct

experimentation on this phenomenon has been carried out, observations made during the survey work of two seasons have thrown some light on its causes.

The following factors all appear to cause failure of the carpels to reflex properly :—

(*a*) bug puncturing, if it be heavy, causing appreciable breakdown of lint, or if it occur along suture lines causing proliferation of inner boll wall tissues at these sites ;

(*b*) appreciable staining of the lint by internal boll disease ;

(*c*) fungal or bacterial lesions along the suture lines, or at the base of the boll ;

(*d*) damage, mechanical or pathological, to tissues of pedicel or stem, causing interruption of food and water supply to the developing boll ;

(*e*) " physiological," either inherent in the plant or imposed by unfavourable growth conditions.

A strain may therefore be a " bad opener " either through inherent physiological defect or through inherent relatively high liability to damage from causes (*a*) to (*d*).

Strain 6250 has the reputation of being a good opener. In the survey work here reported on, this strain has been found to possess characteristics resulting in its being relatively little affected by bug puncturing, internal or external boll disease. On the other hand, 5143 and 929 were notable examples of strains in which " bad opening " was caused by parasitic attack. It may well be that the good opening qualities of 6250 are merely a reflection of certain inherent characteristics rendering it relatively little liable to parasitic damage to developing bolls.

Elaboration of a Simple Technique of using Stainers as inoculating Instruments in Controlled Inoculation Experiments, with minimal departure from natural conditions.—Reference has already been made to the need for greater knowledge of the response of the cotton boll at all stages of its growth, to bug feeding both in the presence and absence of micro-organisms introduced thereby. An essential preliminary to direct experimentation with this end in view, is the development of a suitable technique.

Briefly, in order that data obtained from analytical survey methods such as those here reported on may be fully interpreted, it is necessary that " synthetic " studies along the following lines be instituted :—

(*a*) a study of the feeding habits of stainers and pentatomids of all instars—particularly their choice of food when flowers and bolls of all ages are freely available to them ;

(*b*) the reaction of bolls of all ages to bug feeding ;

(*c*) the reaction of bolls of all ages to infection by the organisms of internal boll disease ; and

(*d*) the efficiency of all instars of stainers and pentatomids as vectors of internal boll disease.

A satisfactory technique for (*a*) has been developed and has already been used by Rainey in preliminary experiments.

A study of (*b*) involves (i) the controlled breeding of stainers with safeguards against their being vectors of internal boll disease, and (ii) the feeding of such insects on bolls of known age, the bolls being protected throughout development from any other insect attack. Methods previously employed by Pearson at Barberton satisfy all these requirements.

In studies on (*c*) reported on in the literature, the methods used have been artificial in the extreme, and interpretation of the results open to severe criticism on many grounds. The employment of a simple technique of using stainers as inoculating instruments in controlled inoculation experiments, with minimal departure from natural conditions, is regarded as an essential condition for the results of such experiments to have practical significance. Preliminary experiments to this end have been conducted, with highly promising results.

It is not necessary here to describe these preliminary experiments in full. It is sufficient to record that of all methods tried the simplest was also the most efficient. Briefly, this method is as follows :—

Stainers are normally reared in cages, with dry cotton seed as source of food (for the purposes of studies such as this, seed obtained from sterile bolls that have been " bagged " throughout their development to prevent access of plant feeding bugs), and water made available to them on a continuously moist cotton wick. Such " sterile " stainers were readily converted into vectors of internal boll disease by replacing, for a few days, the normal water-soaked wick by a cotton wick moistened with a heavy aqueous suspension of spores of *Nematospora gossypii*, obtained from young artificial cultures on potato dextrose agar. Stainers treated in this way, and immediately thereafter caged singly on sterile bolls two to three weeks old for a few days, regularly led to infection of the bolls. The occurrence of infection was confirmed not only by the presence of the typical staining, but also by microscopic examination of every affected lock.

Parallel exposure of sterile bolls to the feeding of stainers caged on (i) infected lint removed from artificially infected bolls, (ii) intact artificially infected bolls, and (iii) sterile cotton seed and plain water only, resulted in a proportion of successful transmissions by stainers of

group (i), still less successful results with (ii), and no transmission with (iii).

Many details still require to be worked out, and the results amplified and confirmed, but it can be confidently stated that the method described opens up many lines of experimentation on internal boll disease, in addition to (*c*) and (*d*) above. As a notable example, extension of the method to other fungi might well, in an indirect manner, provide information on the mechanism of transmission, which is still obscure.

It is also worthy of mention that these experiments have abundantly confirmed the basis of diagnosis of internal boll disease as distinct from direct bug feeding injury that has been employed in the survey methods of study described above. This basis is the same as that originally described by Nowell in the earliest work on internal boll disease, in which the differences in symptoms between direct bug feeding injury and internal boll disease were observed and clearly described. It is to be feared that clear distinction between the two types of injury has not always been made, and references in the literature to "severe staining" cannot, unfortunately, always be regarded with confidence as evidence that infection by the organisms of internal boll disease was prevalent.

OTHER DISEASES.

Wilt Disease of Cotton.—During February, 1940, a localised outbreak of cotton wilt was discovered in a variety trial field of well-grown plants, the variety trial having been planted on 7th November. The symptoms were striking, conforming with those of the "acute" phase of *Verticillium* wilt as described by Hansford. Extensive vascular browning readily apparent on removal of leaves, conspicuous mottling of leaf laminæ very different from the less well-marked mottling of normal leaf senescence, premature leaf fall, and the dwarfed growth of still green younger leaves, were diagnostic features readily distinguishing infected plants.

By the middle of March a large number of plants was found to be affected by the disease in this one area, none of the varieties appearing to be immune. The disease was not found in any other area at the Cotton Experiment Station. From each of 20 of the affected plants, seed was saved with a view to investigating the possibility of seed-borne infection being a means of dissemination of the disease.

From infected plants, a fungus not fully examined but corresponding generally with *Verticillium dahliae*, was isolated.

Wilt Disease of Sunn Hemp.—A typical wilt disease of sunn hemp

was responsible for appreciable reduction in yield of this crop, varying in severity from field to field. On two fields of granite soil the crop was almost entirely destroyed, a very large proportion of the plants having been killed, while still very small, before the end of December. In other fields close inspection showed that the disease was widespread, a high proportion of the plants being affected, but the plants seemed better able to resist the pathogen. In such plants the disease appeared as longitudinal sunken straw-coloured or dark brown lesions, with typical vascular browning beneath and premature death and fall of leaves arising therefrom. Extension of the lesions longitudinally was rapid, but transversely relatively slow, so that the plants continued to make a somewhat stunted one-sided growth. Only when the flowering stage was reached did a large proportion of the plants finally succumb to the disease, appreciable loss of crop resulting therefrom then becoming readily apparent.

From a number of affected plants a *Fusarium* sp. of the section *Elegans* was invariably isolated in pure culture. On 7th February, 1940, two drums of loam soil were infested with pure cultures of this fungus grown on a corn meal and sand medium, by mixing the cultures with the surface soil. Thirty sunn hemp seeds were then sown in each of these drums, and 30 in each of three other similar drums of uninfested soil. By five weeks later, 25 of the 57 plants in infested soil were showing typical symptoms of the disease, none of the 83 in uninfested soil being affected. From a number of the diseased plants, the same fungus was re-isolated, thus proving its pathogenicity. The fungus has not been further identified, but it may be regarded as probable that the disease is identical with the *Fusarium* wilt of sunn hemp well-known in India and elsewhere.

SWAZILAND

COTTON EXPERIMENT STATIONS, BREMERSDORP AND CROYDON.

PROGRESS REPORT FOR THE SEASON 1940-41.

BY

J. V. LOCHRIE.

Introduction.

The situation of the staff has remained as it was last season. At the request of the Administration the experimental work of the Stations is being carried on as usual, while Mr. Hutchinson has been engaged in the promotion and supervision of native cotton-growing and in assisting the Government food production scheme. Encouraging progress has been made in native cotton-growing in spite of an unfavourable season and a lack of support by the native chiefs. A note on its progress and prospects accompanies this report.

As was indicated in the Programme for the season, much of the experimental work has been concerned with problems of soil fertility. Strain tests of cotton were conducted in collaboration with the Barberton Station, and comparative tests of flint maize and red kaffir-corn strains were continued.

The commerical cotton production—which has been at a low level—showed definite increase and, with the price of 8¼d. obtaining, more growers have been attracted and the acreage is likely to show a further rise. Yields were in general low on account of the scanty and ill-distributed rainfall; these conditions emphasised the low state of soil fertility which is general in the native areas and common on European holdings.

Meteorology.

Bremersdorp.—The rainfall (32″) from September to June is below average and the distribution was unfavourable. The ample winter and early spring rains enabled ploughing to be completed early and the conditions for planting in November were excellent. Cotton and maize became well established and the sunny weather following was ideal for weed control. Until the end of January there was adequate moisture and high temperatures and the prospects for cotton and early planted maize were good. Less than 3″ of rain fell in the six weeks from the beginning of February—much of it in small useless showers. Despite this, cotton on the loam soil developed well, but on the lighter,

sandy section *Alternaria* was prevalent. Subsequent rains in late March eased the position, but the crop did not recover and the season was short. The season was marked by the slight losses due to pests. Bollworm was present, but the attack never assumed any considerable proportions. Stainer entered the crop by the end of February, but in the dry conditions and with the early close of the season, damage was negligible. Despite the apparently unfavourable conditions for its spread, the main loss of crop was due to bacterial disease. *Alternaria* was more conspicuous, particularly on the sandy soil.

Croydon.—The rainfall from September to June was 22″. As at Bremersdorp early conditions for ploughing and planting were favourable, with adequate moisture up to the end of November. By mid-December conditions were dry and early planted maize was only saved by a fall at the end of the month. Cotton made satisfactory growth and development in the hot spell, but by the end of February the moisture shortage, coupled with the good crop setting which had already taken place, led to the shedding of flowers and small bolls. The crop benefited little from the slight rains of March as the young crop had already been shed and no further effective flowering occurred. The average yield of 300 lb. lint per acre is very satisfactory in such a short season and is attributed to the almost complete freedom from pests and diseases.

AGRICULTURE.

Fertilizer Experiment.—This experiment at Croydon, which is now in its fifth year, was planted to cotton. The treatments have been applied annually for five seasons except for P.N., where phosphate with a top-dressing of nitrate of soda replaced the Nil series after three years. In previous seasons high yield increases of cotton and maize were obtained from applications of kraal manure or compost and to a lesser extent from supers, while last season the outstanding feature of the experiment was the high increase in yield and in plant growth from dressings of nitrate of soda. The present season's results are tabulated :

Treatment.	*Rate of application per acre.*	*Yield of lint lb. per acre.*	*Green wt. at 6 weeks. % of P.*
P.	200 lb. supers.	260	100·0
PN.	P. plus 200 lb. Nitrate of Soda ...	294	98·5
KM.	3 tons Compost	276	87·5
KMP.	KM. plus P.	319	128·5
Sig. Difference at P=·05		36·9	28·5

The top dressing with nitrate was delayed owing to lack of rain and remained undissolved until nearly six weeks after planting. That the nitrate had not become available is evident from the green weight samples of plants at six weeks. Following rain the N. effect became increasingly evident in better growth and leaf-holding. The relatively

small effect on yield compared with last season is attributed to the delay in availability of the nitrate and the very short season. The compost this season was of poor quality—containing under 14% organic matter—but despite this the small applications gave good results.

Compost Experiment.—This experiment at Bremersdorp was designed to compare the residual effects of two, four and six tons of compost per acre with annual applications of two tons. In the first season the yields followed the amount of the application while in the second and third years the direct application of two tons outyielded the residual effects of two, four, and six tons, between which there was little difference. In general the results of this experiment have been disappointing and inconclusive. In a later section the results of various experiments on this soil are discussed and the evidence points to the preponderating effect of phosphate. The compost made, though rich in nitrogen, is very low in phosphate and it is considered that information on the best means of utilizing the compost will be obtained from a re-designed experiment using different levels of compost and phosphate in combination.

Strain Trials. Cotton.—Trials of a large number of strains from Barberton were conducted at both Stations. At both Stations also a heavy rain storm after planting caused some loss of seedlings by packing. The effect was greatest at Croydon and considerable replanting was necessary.

At Croydon the history of the crop was one of adequate early rains and high temperatures until the beginning of February, followed by an increasing water shortage which caused shedding of the top crop. The crop was free from bollworm and the yield of nearly 300 lb. lint per acre is excellent in view of the very restricted flowering period of about five weeks.

At Bremersdorp conditions were somewhat similar, with a short flowering period but with a higher rainfall. Bollworm infestation was slight but important owing to the poor recovery in the short season. Stainer first appeared at the end of February but, in the dry conditions and with the early finish of the crop, no loss resulted. The bulk of the loss of crop was caused by bacterial bollrot in the early bolls while *Alternaria* was prevalent early, particularly on the granite. The average yield over the trials here was just over 300 lb. lint per acre.

The comparative results were inconclusive ; the strain differences were in general small and rather contradictory in the three sets of soil conditions on which the trials were made. The strains from the 920 family were the least attractive, particularly on the poorer granite soil at Bremersdorp.

Seed Disinfection.—To complete the investigation referred to in earlier reports an experiment was designed to afford information on the effect of cottonseed disinfection on seedling loss through soil-borne organisms. The treatments used were seed treated with proprietary mercurial preparation, acid-treated seed and mechanically delinted seed. The dry and sunny conditions did not favour the development of seedling diseases and no reliable results were obtained.

Rotation Crops.

The dry season was less favourable to cereal and legume crops than to cotton. Early planted maize at both Stations was the most fortunate and produced satisfactory crops, but later planted crops suffered severely from moisture shortage.

Fertilizer Experiment: (A).—The combined fertilizer and rotation experiment at Bremersdorp was planted to maize this season, the third since the experiment started. The rotation is alternate maize and cotton, except for the Nil (*b*) series which is continuous maize. The fertilizers are applied in alternate years, to the maize only, except for KMP (*b*) which is applied annually. The treatments and yields are tabulated.

Treatments.	*Rate of application, lb. per acre.*	*Yield of grain. lb. per acre.*	*Plant weight. % of Nil (a).*
Nil (*a*)	... ...	1,460	100·0
Nil (*b*)	... ...	1,450	73·5
P.	200 lb. supers.	1,890	120·0
KM.	8,000 lb. compost	1,800	127·0
KMP (*a*) ...	KM. plus P.	2,180	151·0
KMP (*b*) ...	KM. plus P.—annually	2,690	185·0
Sig. difference P. = 0·05		275	23·8

The maize in this experiment was planted early and the crop was made before the moisture shortage became acute. The increase in plant weight of Nil (*a*) over Nil (*b*) is significant and was most marked on two blocks on the lighter soils. This beneficial rotational effect of cotton was not borne out by the final yields. This may be attributed to the fairly high witchweed infestation, as the extra year's control by hand-picking on the continuous maize plots would tend to offset any beneficial value of the rotation, particularly in a season when moisture was limited.

With the other treatments, the yields follow the same trend as the plant weights. The highly significant yield increase of the series KMP (*b*) over KMP (*a*) indicates a considerable residual value from the application made to the cotton crop last season. Sufficient evidence of residual fertilizer effects is not yet available, but an experiment noted in the Report of 1938–39 indicated highly significant

residual effects of kraal manure, while those of phosphate were inconsiderable.

Fertilizer Experiment (*B*).—Preliminary experiments at Bremersdorp on loams of doleritic origin have indicated a high response to phosphates, while results from potash have been inconclusive. On the sandy soil at Croydon good results followed phosphatic manuring, particularly in the seaons immediately following the opening of the Station. Small applications of kraal manure and compost gave relatively higher returns than at Bremersdorp and excellent results were obtained from dressings of nitrate of soda.

This season experiments were started at both Stations with applications of N., P. and K. at different levels and in combination. The layout was planted to maize and data obtained on growth, flowering, yield and effect on witchweed. It is proposed to present the results in full after further investigation. A summary of the main findings is given.

Bremersdorp.—The experiment was planted on the loam and, despite the limited moisture and fairly heavy witchweed infestation, fair crops were reaped.

(*a*) Yields ranged from 1,260 lb. per acre from the unfertilized plots to 2,480 lb. from NPK. Owing to the dry conditions, the N. top dressing was late, but despite this the yield increase from N. was significant. The outstanding factor was P., 300 lb. supers increasing the yield by 1,000 lb. per acre.

(*b*) Plant weights also showed the outstanding effect of P. both in early and late samples.

(*c*) Tasselling and silking were significantly earlier in phosphated plots.

(*d*) Witchweed counts showed a highly significant reduction in phosphated plots.

(*e*) No significant differences between any of the treatments was shown in grain/straw ratio.

Croydon.—A similar experiment was planted on the sandy soil. Control measures have markedly reduced witchweed here and good crops were reaped in the limited moisture conditions. A feature of the crop was the outstandingly healthy appearance of plots receiving K. or N. in the dry period from February onwards.

(*a*) N. and K. gave equal and highly significant increases in yield.

(*b*) K. showed high increases in plant weight. Increase also followed the use of N., but at the time of sampling, the effect of N. had not fully shown up, the top dressing having been unduly delayed.

(*c*) The counts of witchweed plants indicate a reduction in all plots receiving K. or N.

(*d*) No significant differences in grain/straw ratio appeared.

The varying nature of the results from the different soil types of the two Stations is interesting. On the loam at Bremersdorp phosphate was the outstanding factor in increasing growth and yield, while at Croydon potash and, to a slightly lesser extent, nitrate of soda was most important. Both Stations afford indications that reduction in witchweed—at least of witchweed plants appearing above ground—followed the application of the fertilizer of most importance for plant growth and yield. All investigations on witchweed emphasize the complexity of the problem and the possible effects of soil fertility require further attention.

Cultivation Experiment.—Reference has frequently been made to the lack of adequate crop cultivation and weed control, particularly in native gardens. Any hoeing which the crop may receive is delayed until the weed growth has seriously affected the crop and made the labour of hoeing very arduous. The present simple layout was designed to demonstrate the effects of an early hoeing on yield and on the work involved in weed control. In addition, the effect of phosphate on early and late weeded maize was investigated. The main difficulty was to find a piece of land which would give weed conditions at all comparable with those found in native plots. The site chosen was on land recently ploughed after a long term in grass and the native system of ploughing in the broadcasted maize was adopted. The following is a summary of the results :—

(*a*) Though weed growth was less than in nearby native crops, the early weeding increased yield by 35%.

(*b*) The effect of 200 lb. supers was high, increasing the yield by over 80%.

(*c*) The early and late weeding combined was no more laborious than one late weeding and obviously prevented weeds from seeding.

Cereals.

Selection and Strain Tests.

Maize.—Progeny tests of the three promising white flint families were conducted at both Stations. Conditions were unfavourable; there was definite moisture shortage at Croydon, while at Bremersdorp this was aggravated by considerable witchweed infestation. These harder conditions were very useful to test the C.1 derivatives, which have done so well in recent years. This family is bigger in growth than the others and there was always a doubt of its holding on in bad

conditions. This season the C.1 strains did not show the yield superiority of the previous wetter seasons, but still equalled the best of the other lots, and they can now be issued for general cultivation.

Kaffir Corn.—Selection work on this crop is now confined to mass selection in bulks of the best strains. Progeny tests were conducted at both Stations and little variation in growth or yield occurred inside families. As a result it has been decided to mix the progenies as bulks of each strain. Some differences in plant type exist between strains, *e.g.*, Strain 127, which is a shorter-stemmed type than the others. Before a final decision is made a combined strain and spacing trial is necessary.

Miscellaneous Crops.

Sunflowers.—A black and a striped variety were grown and yielded well. Mass selection was carried out to maintain the seed supply.

Sunnhemp.—This crop is grown to supply material for compost making. The growth was not so good as usual, but the crop was pest- and disease-free. Samples cut at ground level in the early flowering stage gave green weights of 18,000 lb. per acre.

Velvet Beans.—The crop was planted early and made excellent growth and unlike Sunnhemp it is a prolific seeder. It is a very useful crop for forage or compost making, being a heavy yielder and easy to handle. Green weight samples taken when the first pods were forming gave a yield per acre of 31,000 lb.

Dolichos.—This crop is planted mainly as an attractive one for American bollworm. The green weight per acre was about half that of velvet beans and the flowers and pods are heavily attacked by Cantharides beetles.

Soya Beans.—In addition to the standard Y-1 variety a number of other non-shattering strains from Potchefstroom were grown. The crop made poor growth and the drought from February onwards resulted in small yields. Some of the new strains may be of value as they are earlier than Y-1.

Groundnuts.—Selection work and cultural experiments have been discontinued and bulks only were grown. The dry period coincided with the flowering of the crop and the yield of 500 lb. per acre is the lowest yet recorded on the Station.

Cassava.—Owing to its popularity with the Station labour an increased amount of this crop is now grown. It yields well even in poor conditions and new boys arriving as labourers quickly appreciate it. It, together with pigeon pea, is worthy of extension to native areas as supplements to the sometimes scanty food supplies.

Summary.

(1) The season was marked by a rainfall below average. At both Stations the season was short. Insect pests, particularly at Croydon, were not important, but at Bremersdorp considerable loss occurred through bacterial bollrot.

(2) Cotton strain tests were carried out in conjunction with the Barberton Station.

(3) A series of fertilizer experiments was conducted both on cotton and maize. In addition to the experiments which have been running some years, a further series was started at both Stations and the main findings are given. At Bremersdorp all results indicate the primary necessity of phosphate for plant growth and yield, while potash and nitrate of soda gave excellent returns at Croydon. The application of compost gave good results.

(3) The effect of cotton on the subsequent growth of maize was good, but the complication introduced by witchweed infestation affected the final yields. The experiment will have to run for some seasons more before the real effect of cotton can be assessed.

(4) The beneficial effect of early weeding was demonstrated.

(5) Strain and progeny trials of Flint Maize and the early maturing kaffir corn lots were carried out. The conditions were unfavourable for all except early planted cereals and afforded a good test of the strains.

(6) A range of other crops, mainly legumes, was grown. Groundnuts and beans grown for grain did not do well, but others grown for forage or compost making were satisfactory. Of these the best was velvet beans.

PROGRAMME FOR THE SEASON 1941-42.

Bremersdorp and Croydon.

The experimental work will follow the lines of that of the previous season, with additions and modifications in the light of the results so far obtained.

1. Trials of cotton strains from the Barberton Station will be carried out.

2. In earlier reports mention has been made of occasional heavy losses of cotton seedlings from soil-borne diseases. Conditions following last season's planting were dry and sunny and the experiment designed to obtain evidence of the effect of seed disinfection afforded no data on this point. The experiment will be repeated in the coming year.

3. Any reference to the agriculture of the country inevitably stresses the general low level of fertility, particularly in the native areas. The continuous cereal cropping, inefficient cultivation and the non-return of manures to the land have resulted in poor plant growth—this past season native cotton plots were observed where growth was a matter of inches only. Such conditions have influenced the experimental programme and much of the work is devoted to problems of soil fertility.

(*a*) The experiment on the loam at Bremersdorp, comparing direct and residual effects of compost, is discontinued. The results during the term of the experiment have been rather inconclusive. All fertilizer experiments on this soil indicate the need for phosphatic dressings and it is considered that a re-design of the experiment with different levels and combinations of phosphate and compost will be more valuable.

(*b*) The combined fertilizer and rotation experiment at Bremersdorp will continue. The effect of cotton as a rotation for maize was excellent in improving plant growth, but the final results were masked by the witchweed factor and the experiment will need to run some time before definite conclusions can be drawn.

(*c*) The fertilizer experiment at Croydon, which has run for five seasons, is now discontinued in favour of more complex layouts. The features of this experiment have been the excellent returns from small applications of compost, and the very marked effect of top dressings of nitrate of soda.

(*d*) The experiments at both Stations to test the effects of N, P, and K at different levels and combinations will be continued on maize, while a further series on cotton is to be added. The projected experiments will cover the same soil types as last year with the addition of one on the granite at Bremersdorp. It is on the latter that *Alternaria* was so prevalent in the past season and the experiment will afford opportunity to consider the possible effects of the fertilizers in improving leaf holding.

4. At Bremersdorp an experiment on bush fallow and other restorative crops is projected. The comparisons will include bush fallow, continuous cereals, grass and pigeon pea, with various lengths of break in the continuous cereal cropping. The present system of native agriculture consists of broadcasting the seed in spring and ploughing it in. Individual plots are small and the rough ploughing-in of a weedy cover, together with the broadcast cropping and inefficient hoe cultivation, lessen the tendency to soil erosion. The trend of development is towards the production of a finer tilth, with line

planting and subsequent inter-cultivation. The inevitable extension of the use of harrows, planters and inter-row cultivators will tend to increase field size and the danger of erosion. The experiment proposed is intended to afford information on the suitability of different covers as a break in the cropping system.

5. Selection work on the cereals has been simplified by the results of recent strain trials. Some differences in plant growth exist between the successful kaffir-corn strains, and before final recommendations are made it is proposed to carry out combined spacing and strain tests.

6. Other crops such as groundnuts, soyas and sunflowers, on which selection work or cultivation experiments have now terminated, will be grown to maintain the seed supply.

NOTE ON NATIVE COTTON PRODUCTION.

BY
H. HUTCHINSON.

Introduction.—The Swazi is not a skilful agriculturalist and the recent transition from the hoe to the plough has brought in its train too easy an extension of the cultivated area into land hardly suitable for the prupose, rapid deterioration of soil fertility and multiplication of weeds, including *Striga asiatica*. The consequent reduction of yields, combined with increasing pressure of the native and cattle populations on the land, has thrown agriculture into confusion. Diminishing returns have led to under-nourishment and lethargy, thence to less attention to cultivation and so to further reduced yields. In spite of native agriculture being concentrated almost solely upon food production, the Territory has not been self-supporting in this respect and imports of maize from the Union have been considerable.

Apart from a little tobacco and cotton, there has been no common cash crop and such money as the natives have has come from labour in the Territory, on the Rand gold mines and, in recent years, from the sale of cream during the summer months ; agriculture has been regarded as a dire necessity and not as a means of making money. The project for increasing native cotton production in the Territory is regarded, therefore, more as an opportunity to introduce a new outlook on agriculture through the medium of the crop, than merely to promote an extension of the cotton acreage.

The project was not an ambitious one and involved only the appointment of six former native employees of the Corporation as cotton demonstrators. These men live at their own homes in native

areas and with the assistance of their families demonstrate in their own cultivation the crop husbandry which it is desired that the peasants should adopt. They are allowed two days per week for their own work and on the remaining four have to carry the gospel to their neighbours.

The Season's Work.—In the past, under the stimulus given by the Corporation's officers, some natives have grown cotton with success, but in recent years, following the withdrawal of the Corporation's active intervention, interest has declined and in 1939–40 there were only two or three growers. On the inception of the cotton project, intensive propaganda was begun in favour of the crop on the grounds of its drought resistance, value as a rotation crop for maize, immunity from attack by witchweed, cash return, importance of the lint as material for war supplies, etc. The planting season was rather unfavourable, but in the end over 80 individuals planted plots of varying sizes, totalling about 120 acres. In the majority of cases cultivation was poor, the main preoccupation naturally being with food crops, and as, often enough, the poorest land had been allocated to cotton, growth was often slow and disappointing. In some cases the crop was soon overwhelmed by weed growth and abandoned ; in others the soil was so infertile that after two months the cotton had attained a height of only six inches. In other cases the crop after a slow start, came on very well and astonished the growers by the way it stood up to a severe drought later in the season, when food crops were going off badly. This experience proved to be a great recommendation to the natives and many had the satisfaction of realising a very useful amount of cash for their crop at the end of the season. The very dry weather enabled the growers to pick their seed cotton in clean condition.

Marketing of Seed Cotton.—The purchase and marketing of the seed cotton is undertaken by the writer on behalf of the Administration and, having regard to sale prices for lint, ginning and marketing charges and cost of the seed originally issued free, maximum prices are paid. Two grades are recognised : Grade I—mature, clean, unstained and entirely free from leaf trash, was purchased at 2d. per lb., and Grade II—slightly stained or immature and with only a very small amount of leaf matter, at 1½d. per lb. Dirty cotton is sent back to be sorted over and cleaned. Purchasing depots have been established at convenient points and there at intervals seed cotton is taken in and paid for. The natives, while professing dismay at the smallness of the price and of their returns, are secretly glad to have this money at a time when receipts from cream are falling off and they are for the first time realising the usefulness of a cash crop.

Yields.—Including the crop from a few schools and from

demonstrators' plots the total production was 21,941 lb. of seed cotton, compared with 1,436 lb. in the previous year, and the peak of 10,335 lb. in 1937. The average yield from native plots was 165 lb. per acre, compounded of an average of 186 lb. per acre on private individuals' own land and 128 lb. per acre on land grudgingly worked by the natives for the benefit of their royal house. These yields are very low and indicate the prevalent low standard of soil fertility and of cultivation, but at the present price of 2d. per lb. the average return for private persons is 31s. per acre. Even below this return many growers, counting the occasional labour of their families at little cost, regard the crop as profitable. At the other end of the scale yields up to 660 lb. per acre have been obtained, this grower receiving more than £15, while another with a much lower yield per acre received over £16. In the great majority of cases food crops were very poor or had failed altogether, so that cash from cotton sales was very useful for purchasing imported maize and demonstrated the desirability of a variety of crops.

General Agricultural Considerations.—The greatest obstacles in the way of any extension of the cotton acreage are the smallness of the ordinary man's returns and his conviction that agriculture cannot pay for the work that must be put into it. The common reply to suggestions that cotton should be grown is that there is too much work in the crop—" You have to hoe it twice ! " The only course is to insist on the two hoeings for cotton and to try to convince the people that if they would do the same for their maize and kaffir-corn they would get very much better yields.

Progress in agriculture is sadly hampered by the people's poverty in money and equipment, though generally they own substantial herds of cattle. Their only implements are a plough and a hoe, both often practically worn out, and such a simple matter as carrying out kraal manure to the land is complicated by lack of the necessary equipment. A shovel and a petrol tin are rarities. Until very recently few natives have realised the benefit of using kraal manure and many have been deterred by the labour involved. It is hoped that the use of worn dam scoops obtained from the P.W.D. will help to popularise the practice. Where kraal manure is not available attempts are being made to introduce green manuring with sunnhemp.

The cultivators are in great need of sufficient money to purchase adequate equipment. As small sums obtained from the sale of cream are swallowed up by daily necessities, this can best come from the sale of a cash crop. Over large areas of Swaziland cotton can fulfil a most useful role in this respect and promote a slow and gradual rise in the standard of living.

The Prospects for Next Season.—The prospects for next season are regarded as encouraging. Almost all the well-disposed took up cotton cultivation in the first year and their results have been such as to convert many who were sceptical. It is hoped that in the coming season, in spite of many of the younger and less conservative men having enlisted in the African Auxiliary Pioneer Corps, there will be a considerable increase in the number of growers and in the average yield per acre.

Summary.

A short account is given of the native agricultural situation in the Territory and the place that cotton might take in the system is indicated.

Some 80 growers planted the crop, compared with two or three in the previous year, and 21,941 lb. of seed cotton was produced, compared with the previous best of 10,335 lb. in 1937.

It was a difficult season, with a short rainy period, and the average yield from cultivators' own plots was 186 lb. per acre. Much of the land planted to cotton was very poor, however.

Marketing arrangements are described. The prices paid for seed cotton were :—Grade I, 2d. per lb. ; Grade II, 1½d.

Note.—In addition to the work on cotton described above, the writer was occupied in the supervision of part of the Administration's scheme for food production by direct labour on land placed at their disposal by European farmers. It is satisfactory to record that in spite of the severe drought, which ruined food crops in neighbouring native areas, reasonably good yields were obtained and the grain was disposed of direct to the local inhabitants.

SOUTHERN RHODESIA

PROGRESS REPORT FOR THE SEASON 1940-41.

BY

G. S. CAMERON.

INTRODUCTORY NOTE.

In the concluding remarks of the Introductory Note to the Progress Report for 1938–39, the views were expressed that if the then price level of cotton were to be permanent, one could abandon all idea of cotton becoming a crop of major importance to Southern Rhodesia. But if currency or other problems necessitated, the country could produce good quality cotton in useful quantities. Several of the "other problems" have arisen since then with the result that the Government has adopted measures which will mean an increase in cotton-growing within the Territory far ahead of anything visualised in recent years.

The first of these measures is the Government's decision to guarantee cotton prices for a period of five years. The second is the Government's intention to manufacture absorbent cotton, and to set up spinning mills. Other factors are entering into the situation, but these are outside the scope of this note.

The guarantee of fixed prices over a definite period has had an immediate effect, and farmers are asking for seed on a scale not known for many years. This does not mean that there is any wild stampede into cotton-growing again, but more farmers are taking it up as a rotation for maize, while others, in more remote areas, are taking it up with keen, but guarded optimism. It may be a year or more before the full effect of the Government's policy can be assessed, but there is good reason to believe that cotton will be grown in ever increasing quantities to the benefit of the farmers in particular, and the country in general. Few realise that maize acreages could be reduced by as much as 20%, cotton substituted, and yet the total maize production increased by the rotational benefit of growing cotton. Also, there will be considerable benefit to the cattle industry. Concentrated feeding stuffs, at a reasonable price, are always a problem to stock owners. In the past, sufficient cotton has not been grown to give the cattle industry its full requirements of cotton seed. This position need not arise in future, and for every extra acre of cotton that is grown it should be possible to provide concentrated food for one or more additional animals.

The guarantee of good prices should give a fillip to the native cotton-growing industry. Fluctuating prices were something which the average native grower could not understand, a fact which is easily realised when one considers the number of Europeans who find the same difficulty. But natives are suspicious of what is beyond their comprehension, and it has been uphill work trying to overcome their dislike to trying out cotton. The Native Department has taken over the responsibility for cotton propaganda in the Native Reserves, and it is confidently expected that this will lead to increased production.

Ginning operations have been transferred from Bindura to Gatooma, and a certain amount of unavoidable delay has occurred in ginning this season's crop. The centralisation of all cotton work at Gatooma should lead to greater efficiency and economy. Gatooma is more centrally situated for the country, as a whole, and possesses the additional advantage of having a plentiful electric power and water supply.

The Cotton Research and Industry Board functioned satisfactorily, and will continue as at present, until the end of the existing financial year. It may then become necessary to alter the constitution of the Board as it has been made responsible for the further development of cotton industries contemplated by the Government.

COTTON STATION, GATOOMA.

PROGRESS REPORT FOR THE SEASON 1940-41

Meteorology.

Early, and good rains in October promised well for planting, and these were succeeded by light showers about the middle of November when the bulk of the cotton was planted. From that time until the end of December there was no more effective rain, and the season deteriorated into one of the most exasperating on record at Gatooma. From about Christmas until the end of February, rains were heavy and continuous, and then closed down, with the exception of four scattered showers in March which were too light to be of any use. Early-planted seed came up very unevenly, and seedlings continued to appear above ground over a period of six weeks. The result was that cotton fields, plots, and progeny rows, showed many blank spaces, and much irregularity in the size of plants. In some instances, where it was hoped to obtain quantitative figures, these were not procurable. Late-planted trials gave low, but regular

yields in contrast to early plantings. The total rainfall amounted to 33·01 inches compared with 33·20 inches the previous year, but the incidence of the rainfall made all the difference between a good and a very bad season.

Agriculture.

About forty acres of additional good land have been stumped, cleared and ploughed. It will be brought into cultivation this year, and should prove a useful source of additional revenue. An equivalent area of poor land may be put out of cultivation, and laid down to permanent pasture.

Mention was made in the previous year's Report of the practice of leaving autumn ploughed land " in the rough " instead of breaking it down with a Cambridge roller, or a disc harrow. This year's experience bears out what was said before, but it may be amplified by stating that the Cambridge roller is the better implement for the job. Disc harrows are inclined to make too fine a tilth,whereas the Cambridge roller leaves the land in the desired condition after autumn ploughing, that is it crumbles the ridges without pulverising them. In Southern Rhodesia, where most of the commercially grown cotton is planted by machine, it is very necessary to have the land in good tilth soon after the first spring rains. This also applies to the preparation of land for maize, although not to such an extent, as there is not the same necessity to get maize planted early as there is with cotton.

This year the land was well prepared, and in good condition by planting time. Although the season was such that plant growth was irregular, as mentioned above, the cotton crop ripened very evenly, and there was only one picking. This is rather surprising when one considers the uneven start of the crop. Short plants which appeared late above ground in the seedling stage, ripened off at the same time as taller plants alongside which had benefited from a better start. This is contrary to what one would expect, and is difficult of explanation. The theory is put forward, for lack of a better, that some of the seed remained moist underground before actual germination, and that a certain amount of natural vernalization occurred. With the maize crop, throughout the country, there was the same irregularity of growth, but the ripening was uneven, and late plants produced light cobs with little grain in them. Maize yields were about 50% of what they were the previous year, whereas cotton yields were about 66%. The actual agures are :—

	1939–40.	1940–41.
Maize	16·3 bags per acre	8·0 bags per acre.
Cotton...	456 lb. seed cotton per acre	294 lb. seed cotton per acre.

Compost Trials.

Three composted cotton trials were carried out, two of them on very poor soil, and a third on slightly better land. The third trial was made in order to find the effect of harrowing-in compost instead of the usual practice of ploughing it in. These trials were merely incidental to, and part of, a larger set of trials to assess the effect of cotton, and composted cotton on subsequent maize yields.

Field C.C. Composted Cotton Trial, 1941.

Two treatments (1) No Compost. (2) Compost ploughed in at 5 tons per acre. One-eighth acre plots, each treatment replicated eight times.

Treatment.	*Yield seed cotton in lb. per acre.*
5 tons Compost per acre	373
No Compost	190
Difference	183
Difference required for significance P = ·05	132

Field B.A. Composted Cotton Trial, 1941.

Two treatments (1) No Compost. (2) Compost ploughed in at 5 tons per acre. Half-acre plots. Each treatment replicated four times.

Treatment.	*Yield seed cotton in lb. per acre.*
5 tons Compost per acre	462
No Compost	236
Difference	226
Difference required for significance P = ·01	175·7

Field C.C. Harrowing and Ploughing-in of Compost.

One-eighth acre cotton plots, replicated four times. 5 tons Compost per acre.

Treatment.	*Yield seed cotton in lb. per acre.*
Compost ploughed in at 5 tons per acre	481
Compost harrowed in at 5 tons per acre	265
Difference	216
Difference required for significance P = ·05	182

The first and second of the above trials confirm the results of previous years. The third trial was made as the result of a discussion on the availability of compost to the young seedling, the argument being that compost harrowed in should be more readily available than compost ploughed in to a depth of nine inches. The difference in treatment was noticeable throughout the growing season, and it soon became evident to the eye that the compost ploughed-in plots would yield better than the compost harrowed-in plots. Added to this, there are good and valid reasons for ploughing in compost instead of harrowing it in.

Maize compost trials were carried out, but owing to the unevenness of the plot yields they gave no significant results. This may have been

due to the season, but a more likely explanation is that the plots were situated conveniently close to the Native Compound, and pilferage was suspected.

Livestock.

The fattening of steers for the Cold Storage Commission had to be discontinued as time was not available to attend to the purchase of high grade animals. In order to keep up the supply of compost it was decided to fatten animals, on contract, for a local firm of butchers. The arrangement worked satisfactorily and at a profit, and the main object, the maintenance of an adequate supply of compost, achieved. There is, however, more than a commercial aspect in fattening cattle on a place like the Cotton Station, and it is hoped that it will be possible to obtain high grade "weaners" next year, and feed them for two seasons. When demonstrating the value of cotton seed as a concentrated food for fattening purposes, farmers are not impressed by mediocre looking beasts, and it is better, when possible, to have on view the best grade animals procurable.

Implements and Machinery.

The low pneumatic-tyred wagon designed and built on the Station, and referred to in last year's report, has continued to give satisfactory service. It has been commented on favourably in the local Press, and by a number of farmers. As usually happens, it has been used for purposes for which it was not designed originally, and has been put to more severe tests than its construction justifies. Nevertheless it has been in almost constant use throughout the year, and is standing up to rough usage even better than was expected.

Further work has been carried out in attempting to make a serviceable compost spreader, but so far without success. It has not been possible to give the time or attention that this work merits, but it is hoped that a further effort will be made next season.

Genetics and Breeding.

It was stated in last year's Progress Report that sufficient seed of the strain 7.L.1 would be available to meet requirements, and that the former strain G.5.123 would be withdrawn from commercial use. This statement was premature, and a certain amount of G.5.123 had to be issued to meet late demands for seed. It was hoped that there would be sufficient 7.L.1 seed to meet the following year's requirements, but again it is necessary to fall back on G.5.123. This is due to the large increase in the demand for planting seed as a result of the Government's policy in guaranteeing prices for the next four years.

Increase plots of two of the strains mentioned in last year's Progress Report were grown in addition to another which was chosen after the Progress Report had been posted. These were 9.L.36, 6.C.6, and 9.L.18. The former two have yielded and opened well, but their lint is not up to standard. Although a great many single-plant selections were taken from them in the field, the majority were rejected after laboratory examination. 9.L.18 is in a different category as regards lint character, and on this year's performance it promises to do well.

Single-Plant Selections.—Over four hundred single-plant selections were made in the field, but three-quarters of them are likely to be rejected by the time laboratory analyses are completed. The reason for the increase in the number of primary selections is that no attention was paid to lint quality when selecting in the field. Ginning percentages within strains and progeny rows, were erratic. It is thought that this may have been due to the season which caused great variation between plants. Ginning percentages on the whole were lower than in the previous year. Lint length varied greatly, again possibly due to the seasonal influence. There was also much variation in the strength of the lint.

All the 1939 single-plant selections were planted out, but these did not come up well, and will require to be replanted. Fortunately sufficient seed was retained to enable this to be done. The 1940 selections did better, owing perhaps to slightly better soil conditions, but even so, the lines were patchy and the plants irregular in size.

Colchicine Treatment.—Permission was obtained to ratoon the 1939 treated plants. Flowering records were taken and graphed. These correspond very closely with the graphs of the previous year, but some of the individual plants differed in their behaviour from the previous season. Some plants, which produced normal leaves originally, developed thick turgid leaves in their second season's growth. In one instance, plant No. 16, mentioned in last year's Progress Report, reverted to normal. The suggestion then made that this plant was a ployploid no longer holds good. One late, deformed boll which developed and produced seed early in the following season, has given normal progeny. The other plant mentioned, No. 17, failed as a ratoon, but one cutting took root, and produced a very much smaller edition of its parent. Unlike the parent, however, it did not flower well, and these did not develop into bolls. Some of the flowers were artificially pollinated from a Native cotton plant, but only one boll resulted from the cross. The seed will be planted out next season, but whether it will germinate remains to be seen.

The progenies grown from the seed of colchicine-treated plants

much resembled their parents. In no instance did any of them flower as vigorously as some of their parents, but, again, one has to refer to the difficult season in which they were grown.

A number of single-plant selections were taken from the colchicine progenies and of these a high proportion have better lint qualities than their parents. Lint is longer and finer, but whether or not this is due to the treatment cannot be ascertained until it is seen whether the effect is ephemeral. The difference is all the more noticeable on account of the trying season in which the plants were grown.

Acenapthene Treatment. –It was reported last year that seed from Native cotton (*G. herbaceum*, Hutchinson & Ghose) failed to germinate when treated with Colchicine. In order to try and obtain mutations from this cotton, Kostoff's acenapthene technique was employed*. Lamp glasses, lined with acenapthene crystals, were placed over young seedlings. As the treatment appeared to be too drastic, judging by its retarding effect on the seedlings, three of these were allowed to grow to a height of four feet. Supported on a wooden scaffolding, bell jars lined with acenapthene crystals were placed over the upper portion of the main stems and branches for periods varying from six weeks to two months. The results obtained are rather striking. Bolls became elongated without increasing in width to any appreciable extent. This extension of the boll caused indentations or depressions in the carpel walls. There is a definite lengthening of the lint hairs and the seeds appear to be larger, though these have not yet been measured. Out of twenty seeds examined, only five had sound kernels. The remainder had grown normally, judging by outward appearance, but on opening were practically empty. The seed from all three plants will be sown in the coming season and the experiment repeated. Next time, however, only one branch on each plant will be treated, and the others allowed to grow in the normal way. It was not possible through lack of time and opportunity, to measure anther-heads or pollen grains, but it may be possible to do so next season. There are three points about Native cotton worth mentioning. (1) Very strong tough fibre. (2) Small leaves, and (3) Leaf hairs short but very dense. An observation which will be followed up is that few American bollworm eggs were found on the Native cotton plants, although they appeared very attractive to Sudan bollworm moths.

Entomology.

Locusts.—Unlike the previous year's experience, locusts caused no damage either in the hopper or adult stages.

* *Nature.* Volume 142, page 753 (1938).

Jassids.—Jassid attack was fairly heavy in February, numbers increased rapidly in March, and reached their peak about mid-April. Although numerically plentiful, they did not appear to do much damage to the crop.

American Bollworm.—American bollworm attack was late in commencing, and at no time was it very heavy.

Sudan bollworm.—Sudan bollworms were more plentiful than usual. They were numerous towards the end of February, and early in March. From then they were present only in small numbers until the end of April and early in May. The increase in Sudan bollworm population may be traced to volunteer plants from a field where the previous year's cotton had grown exceptionally rank. It was difficult to plough under, and volunteer plants kept coming up from time to time although attempts were made to keep them down. It is feared that the ploughing was not as good as it should have been, a state of affairs brought about by frequent changes in staff, due to war conditions.

Spiney Bollworm.—Formerly spiney bollworms have not been a serious pest on cotton in Southern Rhodesia. This year, however, they were more in evidence than usual. It is not clear why this should be so, and no explanation is offered.

Aphis.—For the second year in succession aphis attack was negligible.

Stainers.—Stainer damage was much less than usual due, possibly, to the very dry autumn. Stainers were so scarce that recording of populations did not begin until April. *D. fasciatus* was present in much greater numbers than *D. intermedius*, while *D. superstitiosus* did not appear at any time during the season. *D. fasciatus* increased rapidly until the middle of May, when the numbers declined just as rapidly, and by June there were very few left.

Termites.—Although no records were made of damage due to termites, it appeared to be worse than usual. It may be that it was more noticeable on account of the poor stands obtained, especially in the increase plots and progeny rows. In any case the damage was sufficient to justify the classification of termites as a major pest of cotton.

Mycology.

Contrasted with the previous year, there was very little Angular Leaf Spot, and no evidence of Blackarm. It is likely that this was due to the short rainy season.

Summary and Conclusions.

The season was not a good one for cotton. Too much rain in too short a period made planting conditions difficult, and the crop grew unevenly, although it ripened off uniformly and well.

The arable land on the Station has been increased by about forty acres of good soil.

Last year's remarks on autumn ploughing, and subsequent cultivation are confirmed and amplified.

In spite of the difficult season in which maize yields were reduced to half, cotton still gave a 66% crop.

Results of compost trials on cotton are given, and the practice of ploughing in compost shown to be better than harrowing it in.

The type of cattle to be fattened in the process of making compost is discussed.

A satisfactory account is given of a pneumatic tyred, low wagon designed and built on the Cotton Station.

Attempts to make a serviceable compost spreader have not yet met with success.

Supplies of the cotton strain 7.L.1 are not adequate to meet the increased demand, and reasons are given.

Small bulks have been made of three specially named strains but only one of them possesses lint that comes up to standard.

Notes are made on the single-plant selections in general, and the variations in lint characters and ginning percentages, in particular.

Reference is made to the further behaviour of cotton plants which were treated with colchicine last year, and to a possibility of lint improvement in some of their progeny.

A description is given of the effect of radiation through acenapthene crystals on a Native cotton. This work requires to be repeated, and better and more detailed information obtained.

Damage from insect pests was not severe, but an increase in Sudan and spiney bollworm is noted, and attention drawn to termite damage.

There was very little Angular Leaf Spot, and no evidence of Blackarm disease.

PROGRAMME FOR 1941-42.

The cotton situation in Southern Rhodesia is likely to develop much more quickly in the next few years, and important changes in policy are about to take place or are pending. Under the circumstances it is not possible to lay down a definite programme for next season. There will be so much time taken up with matters outside the Cotton Station that there may not be sufficient left to carry through even a very modified programme.

The acreages to be planted to the various crops are still under discussion, but they will be much the same as usual, except that forty

acres of new land will increase the total. The acreage to maize may be reduced slightly, and the acreage to cotton increased.

One large variety trial is contemplated, and the trials to find out the rotational benefit of cotton for the succeeding maize crop on poor soil will be completed. A similar two-year trial on better land may be undertaken.

Most of the 1939 and 1940 single-plant selections will have to be re-sown in addition to this year's selections.

The 9.L.18, 6.C.6, and 9.L.36 strains will be multiplied one stage further, and the seed kept in reserve until it is decided whether or not any of these strains should be put into general cultivation.

There are also a number of Station crosses to be carried forward and used as a basis for selections, in addition to other material which requires to be multiplied up in increase plots.

Particular attention will be paid to the lint quality of certain colchicine-treated families. The progeny of the acenapthene-treated Native cotton will be observed closely, provided that the seed germinates, and last year's experiment repeated.

Records of insect pest populations will be taken if possible.

Further work ought to be done on the perfecting of a reliable compost spreader, but this may have to be abandoned, or suspended for an indefinite period.

Compost will be made on the same scale as before, but it is hoped that it will be possible to procure good quality weaner stock, and feed them over a longer period than was necessary when fattening three-year-old steers.

A certain amount of chemical work may have to be undertaken. in connection with the manufacture of absorbent cotton.

ANGLO-EGYPTIAN SUDAN.

PROGRESS REPORT OF THE PLANT BREEDING STATIONS, SEASON 1940-1941.

GENERAL INTRODUCTION AND SUMMARY OF PROGRESS.

The organization of the work continues to follow in general that set out in the 1935/36 Report, viz., headquarters at the Gezira Research Farm and sub-stations at Shambat and Kadugli.

With the provision of ginnery facilities at Kadugli, however, the concentration there of the work directly connected with the Nuba Mountains crop has been carried a stage further, while as a result of the increased scale of the special work at Shambat on Blackarm resistance, the use of the Shambat Farm as a common centre for propagation work has to a large extent been suspended.

At the same time, the division of the body of this Report into sections written by the workers at the different stations in no way implies a rigid geographical subdivision of the programme. Mr. Knight's work is directed to the Blackarm problem of both the Gezira and the rain areas. Mr. Anson and the staff at headquarters co-operate in the testing of cotton strains in Equatoria for which as yet no separate breeding station exists.

Mr. Evelyn has taken over definite portions of the experimental programme at the Gezira Research Farm directed both to cotton and dura (*Sorghum* spp.) but has also assisted with other work there and elsewhere.

The main points emerging from the season's work are briefly as follows :—

The successful production in bulk of Sakel-type cottons carrying a considerable measure of resistance to Blackarm (*B. malvacearum*) now seems more than probable in the near future.

Substrains of the Sakel selection N.T.2 have continued to give good results and their resistance to Leaf Curl disease has been further demonstrated.

An American Upland variety which may prove more profitable than the existing type in the Nuba Mountains has reached an advanced stage in bulk propagation, while a further strain has shown great promise in replicated trials.

Introductions from Uganda have shown promise in Equatoria, particularly as regards earliness of cropping, while locally-bred types gave good yields also.

A sound recommencement of systematic work on the dura crop has been made.*

Gezira Research Farm

BY

H. E. KING AND S. H. EVELYN.

Meteorology.

Rainfall was well below normal. The absence of heavy rains at sowing time proved helpful since exceptionally good germination was obtained by irrigation.

Temperatures were well above normal in September and December, but November was very cool. In general, the season may be considered quite a favourable one for the cotton crop.

Field Scale Cotton Varietal Trials (H. E. KING).

The usual series of replicated tests was carried out, the varieties under trial consisting of sub-strains of X1730 and N.T.2 origin, plus two new importations from Egypt.

Yields were good and results in general clear cut and consistent, both within the series and in comparison with previous trials.

X1730H and X1730J showed promise in comparison with X1730A. Both appeared about equal in yielding powers and Leaf Curl resistance, with slightly higher ginning outturns and more uniform lint. X1730J showed a small increase in lint length.

N.T.2/38 again showed itself an all-round improvement on N.T.2/36 and gave yields approaching that of X1730A. Both it and a further substrain, N.T.2/39, remained almost entirely free from Leaf Curl under conditions in which Domains Sakel showed considerable infection.

Sakha 7, newly imported from Egypt, did not appear to differ from local Domains Sakel, but Sakha 4 gave a somewhat higher yield. Both these importations showed considerable Leaf Curl susceptibility.

* Work on Dura in previous seasons (commencing in 1926–27) has not been included in the Empire Cotton Growing Corporation's publications, but will be found in the reports of the Sudan Government Department of Agriculture. Dura, the staple food crop of the country, occupies some 1½ million acres annually, and in the Gezira takes a definite place in the rotation with cotton.

In unreplicated " inspection plots " small bulks from the Blackarm resistance backcrossing work gave encouraging results. Visual inspection and hand laboratory tests suggested that the backcrosses did not differ at all markedly from their Sakel parent types except in their resistance to Blackarm. In the absence of marked Blackarm infection at the Gezira Research Farm, the only evidence on this latter point was provided by a small plot at Barakat. Here infection was moderately severe on adjacent fully susceptible cotton and the comparative resistance of the backcross appeared beyond doubt.

A range of lint samples from these trials has been submitted for brokers' examination and spinning tests.

Cotton Breeding Work (S. H. Evelyn).

General.—Certain modifications of the technique employed in the Egyptian cotton selection work were introduced in the 1940/41 season.

The practice of adding " Red Leaf " Upland seed to make up any deficiency in the normal progeny seed rate of 10 seeds a hole, for the purpose of aiding progeny seedlings to push through the tough surface soil, was discontinued because of the differential competitive effects which were likely to occur.

The system of random selection of plants to be selfed and the analysis of bulk samples taken at random from each plant in each progeny, were introduced. In the absence of progeny randomization and replication this procedure helps to eliminate environmental effects and allows progenies to be more accurately compared. From the latter the characters " weight of seed-cotton per boll," " weight of lint per boll " and " number of seeds per boll " can be determined and used in selection. " Total number of bolls harvested per plant " was another character added to the selection data. Selection was based solely on the analytical data.

Unfortunately it was not considered possible to introduce the random-progeny system into the programme of work of this or the subsequent season, but it is hoped that at the end of next season it will be possible to reduce the number of selections generally made to about 20 to allow this procedure to be adopted.

Purification of Massey's Selected Domains Sakel.—M.S.D.S. is the main variety used in physiological experiments at the Institute and as the standard Sakel type in the Egyptian cotton selection work. Some doubt as to its purity led to the selfing and analysis of four of the plots grown as standards in the 1939/40 Breeding Plot. These were all sown with the same bulk stock unselfed seed. The single-plant analysis of 233 plants gave the following results :—

TABLE I.

ANALYSIS OF M.S.D.S. GROWN AT GEZIRA RESEARCH FARM, SEASON 1939–40.

Character.	*General Mean.*	*Character Range.*	*No. of Observations.*
Mean Maximum lint length (mm.) ...	42·5	32 — 50	1,165 seeds 233 plants
Lint Index (grm.)	5·3	3·3 — 6·7	212 plants
Weight of 100 seeds (grm.)	11·6	8·0 — 14·3	212 plants
Ginning Outturn (%)	31·4	26·5 — 36·0	232 plants

Wide variation was also detected in lint quality, seed size and shape, fuzz colour and type—naked to fully fuzzed seeds were observed. The maintenance of M.S.D.S. stock by roguing and periodic bulk selection of phenotypically uniform plants in the field (without laboratory examination or progeny testing) has kept the strain uniform in vegetative appearance, but such uniformity does not apparently extend to its lint and seed characters.

As there seems to be no record of the characters of the original M.S.D.S. type it was decided to base selection on nearness to the general means. One hundred selections were made and sown this season as separate progeny lines—each of 35 single plants. The lines were selfed and a random bulk sample of 100 normal unselfed bolls was analysed per line and gave the following results :—

TABLE II.

ANALYSIS OF M.S.D.S. GROWN AT GEZIRA RESEARCH FARM, SEASON 1940–41.

Character.	*General Mean.*	*Character Range.*	*No. of Observations.*
Mean Maximum Lint Length (mm.) ...	43·6	33 — 49	43 bulks 1,075 seeds
Lint Index (grm.)	5·2	4·4 — 6·2	100 bulks
Weight of 100 seeds (grm.)	11·7	10·1 — 13·8	,,
Ginning Outturn (%)	30·7	24·6 — 34·7	,,
Weight of seed-cotton per boll (grm.)	2·59	2·19 — 3·08	,,
Weight of lint per boll (grm.)... ...	0·79	0·62 — 0·97	,,
No. of seeds per boll	15·3	12·8 — 17·8	,,

Pressure of other work prevented the analysis of the single plants, but it was considered fairly safe to select on the bulk analysis data. Although the variation in some of the characters appears to be slightly reduced, it must be borne in mind that the data given in Table II were obtained from bulk pickings from 35 plants per line and those in Table I from single plants.

Again the general means were used as a basis of selection. The selfed seed of twenty-one lines, selected on this basis, was bulked and will be grown as a nucleus stock next season. Three lines, whose character values were almost identical with the general means, will be selfed and observed in next season's Breeding Plot for the purpose of obtaining a nucleus pure stock of seed for future multiplication. Twelve lines which were off type for certain useful characters were also selected for observation in pedigree culture.

Selection Work with Original X1730 *Type.*—X1730 derivatives are superior in yield to Domains Sakel, but are inferior in quality. A plot of X1730 (nearest original seed) was grown at the Farm this season and 100 typical plants were chosen and analysed. Sixteen of these were selected, primarily for lint quality and length, in conjunction with good yield characters, and their progeny will be examined next season. The following values were obtained.

TABLE III.

Analysis of Nearest Original X1730 Grown at Gezira Research Farm, Season 1940–41.

Character.	*General Mean.*	*Character Range.*	*No. of Observations.*
Mean Maximum lint length (mm.) ...	45·4	37 — 49	34 plants (170 seeds)
Lint Index (grm.)	5·7	3·7 — 6·9	61 plants
Weight of 100 seeds (grm.)	10·8	8·2 — 12·5	61 plants
Ginning Outturn (%)	34·8	28·0 — 39·5	61 plants

Selection for Leaf Curl Resistance.—Last season, four plots of M.S.D.S., already referred to, were observed for Leaf Curl incidence. Although planted with the same seed, for convenience the plots were numbered separately. Each plot contained 60 plants and the following numbers were observed with Leaf Curl :—No. 87/39—56 plants ; No. 123/39—37 plants ; No. 133/39—26 plants ; and No. 142/39—38 plants.

Leaf Curl disease is sporadic in occurrence and is generally to be found in isolated areas scattered over a field rather than following any definite system of spread, nevertheless it was thought likely that, for example, the four plants in No. 87/39, which had not apparently contracted the disease, although surrounded by it, carried genes, or some other mechanism, of resistance. Consequently, the disease-free plants were selfed and tested this season against general M.S.D.S. in a Beaven Half-Strip " lay-out." Included in the test was a culture N.T.97/40 (a substrain of N.T.2/39 parentage), which had been selected for resistance at Shambat by R. L. Knight. A line of 35 single plants of each selection was grown from selfed seed and compared with an adjacent line of general M.S.D.S. It was thought that such a " lay-out " would facilitate the spread of the disease.

The experiment was sown at the Farm on 15th August, 1940, and picking was completed by 31st March, 1941. The disease did not make its appearance until 5th April, 1941, and a count at this date gave the following numbers of diseased plants :—No. 87/39—1 plant ; No. 123/39—1 plant ; No. 133/39—27 plants ; No. 142/39—6 plants ; and no plants in N.T.97/40.

As the disease apparently develops better on new secondary growth, the plants were cut back on 7th April, 1941, and a final observation made on 30th April, 1941, gave the following results.

TABLE IV.

OBSERVATIONS MADE AT GEZIRA RESEARCH FARM on 30th APRIL, 1941, IN THE LEAF CURL RESISTANCE EXPERIMENT.

Family.	*No. of Lines.*	*No. of Plants.*	*No. of Plants Infected.*	*% Infection.*	*Mean Number of Plants infected per Line.*	
87/39	4	120	1	0·83	0·25	
Control	4	133	—	—	—	
123/39	18	593	8	1·35	0·44	
Control	18	595	13	2·18	0·72	
133/39	24	758	63	8·31	2·86	S.E. = 0.705
Control	24	795	133	16·73	6·05	
142/39	11	267	17	6·37	1·55	S.E. = 0·46
Control	11	370	45	12·16	4·09	
N.T.97/40	12	377	10	2·65	0·83	S.E. = 0·456
Control	12	412	29	7·04	2·42	

The total number of selected plants was 2,115, of which 99 showed the disease. Of the 2,305 control plants, 220 showed the disease. The general mean number of infected plants per line was 1·43 for the selections, and 3·19 for the controls.

Although not laid out strictly at random it was decided to treat each pair of lines (selection plus control) as a randomised block and examine the data separately for each family group by the analysis of variance. Families 87/39 and 123/39 were not analysed because of the smallness of the infection in both selections and controls. Standard errors expressed as percentages of the general means were in all cases very high, probably because of the uneven spread of the disease, nevertheless families 133/39 ; 142/39 and N.T.97/40 gave a significance over controls exceeding the 1% " Z " value, and the fact that the selections were not strictly randomised should not create a significant result from an insignificant one, so that it can generally be conceded that selection for resistance has had a positive effect. As selfed seed is available from each line in the test the work is being continued next season with an improvement in the lay-out.

In past years it has been observed at the Institute that Leaf Curl incidence varied considerably from strain to strain. Thus, N.T.2/38 has consistently shown high resistance at the Gezira Research Farm and at Shambat, even though many strains which appear highly resistant at the Gezira Research Farm often prove very susceptible at Shambat. Although such observations have been recorded, the above experiment is of interest in demonstrating significantly the value of selection for resistance in a strain classified as almost fully susceptible.

The Cotton Reference Plot.—A collection of types of Old and New World cottons was grown this season at the Farm and a fair number of these were found to be badly admixed or impure ; typical plants

were selfed, therefore, and this work will continue until type purity is obtained.

Breeding and Testing of Dura (*Sorghum* Spp.) (S. H. Evelyn).

(i) *The Dura Type Collection.*—A collection of 244 dura strains was grown and observed for the most important agricultural and genetic characters. Typical plants of each type were selfed. The dura crop in the Sudan occupies over 50% of the total cultivated area and forms the main food of the population. For this reason it was decided to analyse the grain of the type collection for percentage nitrogen, and this work was kindly undertaken by the Soil Research Section of the Institute. Later, it is hoped to extend the analysis to other dietetic components. Two main results of the one season's analysis are worth recording :—(*a*) There was apparently no relation between percentage nitrogen and seed colour, and (*b*) percentage nitrogen was highest in types with the heaviest seeds. The work is being continued.

Table V.

Result of the Dura Randomized Progeny Test at Gezira Research Farm 1940-41.

Progeny.	*Mean Head Weight per Plant* (grm.).	*Mean Grain Weight per Plant* (grm.).	*Mean Gassab Weight per Plant* (Rots.).	*Mean* Threshing per-centage* (%)	*Mean Weight of 100 Seeds* (grm.).	*Mean No. of Heads per Plant.*
Feterita Fayoumi	70·5	52·7	·48	74·8	3·61	Not taken
Feterita Maatuk 1	78·7	55·2	·56	69·5	3·63	,,
Feterita Maatuk 2	69·6	49·6	·48	71·1	3·50	,,
Feterita 1931	70·7	50·7	·50	71·4	3·40	2·1
Dwarf Hegari	44·7	30·5	·29	68·4	1·94	1·6
D(S) 2—1	72·4	49·9	·47	69·0	3·35	2·5
2—2	54·5	36·4	·42	66·6	3·39	2·2
5—1	61·5	41·6	·41	67·3	3·39	1·9
5—2	60·1	39·4	·42	65·0	3·26	2·1
6—1	67·8	46·0	·51	67·6	3·21	2·3
7—1	73·1	49·7	·47	67·9	3·68	2·2
12—1	64·5	42·3	·41	64·9	3·41	1·6
12—2	70·7	48·0	·45	67·9	3·50	1·4
15—1	60·2	37·2	·53	61·7	3·32	1·6
15—2	79·3	54·2	·48	68·4	3·38	2·4
21—2	78·3	54·3	·53	69·2	3·62	2·5
21—2	59·3	39·9	·43	67·2	3·59	1·8
Significant difference =	14·1	10·0	·04	2·5	0·06	0·32
General Mean =	66·8	45·7	·46	68·1	3·36	2·02
S.E. as % General Mean =	24·0%	24·9%	22·6%	4·13%	2·08%	18·3%

* Mean Threshing Percentage is the percentage grain weight per head weight

(ii) *The Dura Random Progeny Trial.*—Last season 80 single plants were uprooted from the variety trial and multiplication plots and measured for head and gassab (=stem and leaves) characters. 17 selections were made this season and treated as progenies in a randomised layout, replicated ten times. The unit plot was a row of 20 single plants. Very poor germination resulted in uneven stands and in addition, unavoidable bird damage and the admixed condition of the material were mainly responsible for the high errors generally obtained in the analyses of variance. Progeny differences were nevertheless highly significant at the 0·1% Z value and the results demonstrated the efficiency of the layout, to determine which was the main object of the experiment. Without correcting for stand the mean character values per plant per progeny were examined by the analysis of variance with the results as shewn in Table V (page 94).

The following correlation coefficients are of interest and were determined from the mean values per plant.

TABLE VI.

CHARACTER RELATIONS IN DURA—GEZIRA RESEARCH FARM, 1940–41.

Relation between	*Value of "r."*	*Significance of "r" for n = 100.*
Head Weight and Grain Weight	+0·988	P at ·001, "r" = ·3211
Head Weight and Weight of 100 seeds	+0·145	P at ·1, "r" = ·1638
Grain Weight and Gassab Weight	+0·856	P at ·001, "r" = ·3211
Gassab Weight and Weight of 100 seeds ...	+0·077	P at ·1, "r" = ·1638
Gassab Weight and Threshing %	+0·220	P at ·05, "r" = ·1946
Threshing % and Weight of 100 seeds	+0·058	P at ·1, "r" = ·1638

Mean gassab weight, a possible measure of soil fertility, gives a high positive correlation with mean head weight and mean grain weight and a slight positive correlation with threshing percentage. Mean weight of 100 seeds is apparently not influenced by soil fertility and has no relation with threshing percentage.

The random progeny test was of great value in many respects, not the least being the working knowledge gained of the crop and the problems likely to be met with in such a form of experimentation. In future the policy will be to observe large numbers of types in the unreplicated type plot and select the most promising for random progeny testing.

(iii) *The Dura Variety Trials at the Gezira Research Farm*, 1940/41.—Two trials containing the same eleven varieties, replicated six times, were sown at the Farm on 20th July, 1940. They differed only in the fact that one was rain-grown and the other irrigated. Unfortunately, owing to a dry spell immediately after sowing, the Rain Trial had to be given a single irrigation to promote germination. The Irrigated Trial

received eight waterings at fortnightly intervals. The unit plot size was 0·0137 feddans. The strains consisted mainly of local types, and selections of Feterita origin. Germination, because of insect-damaged seed, was in general very poor, and as a result, plot stands were very patchy. It was a poor rain year and the Rain Trial started to dry out on 1st October, 1940, and was completely desiccated by 15th October. The total amount of rainfall recorded at the Farm for the period 1st July to 21st October, 1940, was 224·2 millimetres or approximately 9 inches. The Irrigated Trial was reaped on 10th November, 1940. Mainly because of seed admixture and outcrossing a fairly high percentage of rogues occurred in almost every variety—thus in Dwarf White Milo 19% was recorded. Heads and gassab were sun-dried for one week before being weighed. The results are given in Table VII.

TABLE VII.

RESULTS OF THE DURA VARIETY TRIALS AT GEZIRA RESEARCH FARM, 1940–41.
(ROTLS PER SUB-PLOT.)

Varieties.	*Mean Head Weight.*		*Mean Grain Weight.*		*Mean Gassab Weight.*		*Threshing Percentage. (%)*		*% Increased Grain Weight from Irrigation.*
	RAIN.	IRRIG.	RAIN.	IRRIG.	RAIN.	IRRIG.	RAIN.	IRRIG.	
Dwarf White Milo	17·1	22·5	12·4	17·2	38·1	53·6	72·4	76·5	38·7
Feterita Maatuk (Control)...	15·8	18·3	11·9	13·7	56·5	76·3	75·1	74·8	15·1
Feterita 1931	16·0	17·9	12·0	13·3	45·5	65·3	75·0	74·6	10·8
Dwarf Hegari	14·2	17·9	10·8	13·9	50·8	49·6	76·1	77·9	28·7
D (S) 5	15·5	17·2	11·4	13·2	41·2	58·7	73·7	76·7	15·8
Feterita Fayoumi	14·0	16·8	10·3	12·7	40·0	69·9	74·0	75·8	23·3
D (S) 7	13·8	16·7	10·1	12·5	50·8	73·0	73·1	75·0	23·8
D (S) 12	11·2	16·2	8·1	12·0	49·3	62·1	71·7	74·2	48·1
D (S) 21	14·3	16·0	10·7	12·3	47·2	65·8	74·8	77·0	15·0
D (S) 15	11·3	14·6	8·1	11·0	59·3	71·9	71·4	74·9	35·8
Dwarf Feterita	13·0	12·5	9·1	9·2	33·1	44·5	70·3	73·5	1·1
Significant Difference ...	2·81	1·63	2·05	1·41	9·63	9·18	—	—	—
General Mean	14·2	16·9	10·4	12·8	46·5	62·8	73·5	75·6	23·1
S.E. as % of General Mean	17·6	8·5	17·4	10·1	18·3	13·0	—	—	—

Variation due to varieties was significant at the 0·1% Z level for head weight, grain weight and gassab weight.

Although the results of the two tests are not strictly comparable as they are obtained from separate experiments, yet as the trials occupied different parts of the same five-feddan field and differed only in the way they were watered there seems a certain amount of justification in drawing the following conclusions :—(*a*) The Irrigated

Trial gave superior results in head, grain, gassab weight and threshing percentage; (*b*) Varieties differed in their response to rainfall and irrigation. Thus, in grain yield Dwarf Feterita 6603 showed no difference, whereas D(S) 12 showed an increase of 48% from irrigation. Under irrigation Dwarf Hegari gave 2·4% less gassab than when rain grown, whereas Feterita Fayoumi under irrigation showed an increase in this character of 75%. Such tests are being continued as they give valuable information on varietal resistance to drought and tolerance to excess watering. Drought is a serious problem in the rain-grown dura areas and the native cultivator in the irrigated areas of the Gezira does not yet fully realise the harm which excess irrigation can do to his dura crop. Later it is hoped to determine the effects of irrigation and rainfall from a single experiment. The following general conclusions can be drawn from the trials :—(*a*) Dwarf White Milo consistently gave the best grain yields. (*b*) Feterita Maatuk, in respect of grain and gassab, was the best dual purpose type.

(iv) *The Dura Variety Trial at Abdel Magid.*—The seed used in this experiment had been severely damaged in storage at the Gezira Research Farm; germination was therefore very poor and stands so uneven as to reduce most of the varietal differences to insignificance. The test was, however, useful as a demonstration, as although the local dura type was not included, the superiority in yield of the test varieties was sufficiently marked to overcome the natural conservatism of the native agriculturists, who expressed a keen desire for seed. The trial was carried out entirely by the Agricultural Inspector at Abdel Magid and contained the varieties Dwarf Hegari, Dwarf White Milo, Dwarf Yellow Milo, Dwarf Feterita 5985 and Dwarf Feterita 6603.

(v) *The Dura Trial at Talodi* (*Nuba Mountains*).—In the Nuba Mountains, early, medium and late maturing duras are grown every season, but as staff was not available at Talodi to carry out the proposed replicated variety tests for each maturation group, it was decided to grow unreplicated lines of a number of promising types to determine, after a few seasons, which were the best to include in proper variety trials. Thirty types were grown this season at Talodi and gave interesting results, and this number will be increased next season and duplicated at Dilling and Kadugli so that comparisons between these areas will be possible.

(vi) *Experiments to Control Insect Damage to stored Dura Seed and specimen heads.*—The chief pests in the Sudan of stored dura seed and specimen heads are first the moth *Sitatroga ceriallela*, and to a lesser extent the beetles *Tribolium confusum* and *T. Ferrugineum.* These pests apparently occur throughout the Sudan, as most of the specimen

heads and seed samples which have been sent to the Farm from outstations during the last two years have in almost every case been heavily infested with both moth and beetle. Damage to stored seed at the Farm was so severe that it was not an uncommon practice to have to resow 60% or more of the area of varietal trials and propagation plots ; an attempt was therefore made to control these pests. Specimen heads kept in glass cases or cupboards were also so severely attacked as to be often useless for purposes of reference.

At this time, " Katelsousse ", a sulphur-phosphorus dust prepared by Imperial Chemical Industries, was generally employed as a control, but although plentifully used at the Farm and outstations, it was apparently not effective in controlling *Sitatroga* or *Tribolium*, to judge from the condition of the treated specimen heads and seeds stored at the Farm, and the treated samples sent in from outstations.

Dipping heads and seed in a 0·1% water solution of mercuric chloride and potassium iodide was tried and found ineffective. Later, with the kind co-operation of the Soil Research Section, Agricultural Research Institute, heat treatment to reduce moisture-content and harden the seed coat was tried, but it was found that although seed heated at 100°C. had its moisture reduced from 10% to under 2%, exposure to normal atmospheric conditions resulted in the moisture being restored to 8% in 24 hours. It was, therefore, not surprising that heated seed exposed to *Sitatroga* was as severely attacked as the untreated controls.

Finally, at the suggestion of the Government Entomologist (H. W. Bedford) naphthalene was tried and has proved one hundred per cent. effective in controlling both pests. Since its use specimen heads kept in non-moth proof cupboards and seed contained in tins and bags show no damage after eighteen months' storage.

Shambat Sub-station

by

R. L. KNIGHT.

Introduction.

With the propagation in bulk of the first trial lots of Blackarm-resistant Sakel it has been possible, this season, to extend the work of the station. Though the production of Blackarm-resistant Sakel types is still the main objective, and must remain so till successfully accomplished, work has also been started on Blackarm resistance in American Upland strains and on jassid resistance in Sakels.

Meteorology.

Rainfall was about half the normal and again the season was characterised by an abnormal number of dust storms and hot dry winds which caused considerable leaf damage to cotton.

Genetics and Breeding.

(i) *Transference of resistance factors* $\mathbf{B}_1$ *and* $\mathbf{B}_2$ *from Uganda* B.31 *to Sakel.* –During the normal season the eighth Sakel backcrosses to N.T.2 38, N.T.66 38 and X1730H were made. The eighth backcross progenies were sown in the winter of 1940–41 and from then the ninth, and final, backcrosses were made and will be sown in the 1941–42 season. These ninth backcross seed lots are of the following composition (superscripts denoting the number of times each strain has been used as a parent :—

$\{[(B.31\times X1530B)\times N.T.2/36^2]\times N.T.2/37\}\times N.T.2/38^6$

$(\{[(B.31\times X1530B)\times N.T.2/36^2]\times N.T.2/37\}\times N.T.2/38^2)\times N.T.66/38^4$

$(\{[(B.31\times X1530B)\times X1530A]\times X1530E^2\}\times X1730G^2)\times X1730H^4$

In the 1939-40 season some of the backcrossing in the X1730 types was to X1730A instead of X1730H (a more recent substrain than X1730A). This apparently retrograde step was made because it was thought that X1730A was likely to prove more resistant to Leaf Curl under Shambat conditions than X1730H. Since, however, both types were shown this season to be highly and equally susceptible under Shambat conditions, this line of crossing was dropped and only the three lines shown above were carried to the ninth Sakel backcross stage.

Bulk Propagation of Blackarm-Resistant N.T.2 *from Fifth Backcross.*—Over one ton of seed of N.T.2, homozygous for the American Upland Blackarm resistance factor $\mathbf{B}_2$, was produced from a $6\frac{1}{3}$-acre propagation plot of fifth backcross F_3 composition. In addition, two $\frac{1}{4}$-acre propagation plots of fifth backcross N.T.2 homozygous for both $\mathbf{B}_1$ and $\mathbf{B}_2$ and $\mathbf{B}_1$ only, yielded respectively 60 and 61 lbs. of seed. All three plots had been sown at wide spacing at one seed per hole using out-of-season seed.

Bulk Propagation of Blackarm Resistant N.T.2 *and* X1730 *from Seventh Backcross.*—F_2 families from $\mathbf{B}_1\mathbf{b}_1$, $\mathbf{B}_2\mathbf{b}_2$ and $\mathbf{B}_1\mathbf{b}_1$ $\mathbf{B}_2\mathbf{b}_2$ plants in the seventh backcross progenies were grown in the winter of 1940–41. These families were dealt with in a similar way to that outlined in the 1939-40 Report of this substation* and the following homozygous seed lots were obtained for sowing in 1940–41 :—

* The report was not printed in the corresponding volume of last year.

X1730 types : $\mathbf{B_1B_1}$ seed for sowing $\frac{1}{8}$ acre propagation plot and $\mathbf{B_2B_2}$ seed for sowing 2 acres.

N.T.2 types : $\mathbf{B_1B_1}$ seed for sowing $\frac{1}{4}$ acre propagation plot, $\mathbf{B_2B_2}$ seed for sowing 6 acres, and $\mathbf{B_1B_1B_2B_2}$ seed for a small nucleus area.

(ii) *FS.* (*G. punctatum*) *crosses.*—The third and fourth Sakel backcross progenies were grown this season, the latter being winter sown, and pollinations were successfully carried out to make the fifth backcrosses which will be sown in 1941–42. This fifth backcross seed has the following composition :—

$$\{[(\text{FS.2}\times\text{X1530A})\times\text{X1730F}]\times\text{X1730G}\}\times\text{X1730H}^3$$
$$\{[(\text{FS.2}\times\text{X1530A})\times\text{X1730F}]\times\text{X1730G}\}\times\text{N.T.2/38}^3$$

It was demonstrated that two linked factors control the resistance of FS.2. One of these is phenotypically similar to $\mathbf{B_2}$ and is probably identical with it in all respects. The second factor has been called $\mathbf{B_3}$. These two genes together confer considerably more resistance on the Sakel genotype than do $\mathbf{B_1}$ and $\mathbf{B_2}$.

(iii) *Gambia Native* (*G. punctatum*) *crosses.*—The second Sakel backcross progenies were grown this season and the presence of two linked Blackarm resistance factors was demonstrated. As these factors are phenotypically identical with those obtained from FS.2, this line of crossing has been discarded.

(iv) " *Hindi weed* " (*G. punctatum*) *crosses.*—The Blackarm resistance of " Hindi weed " cotton was shown to be due to a single gene which was proved to be $\mathbf{B_2}$.

(v) *Flagging Blackarm-resistant Sakel strains with the Asiatic gene* **R**.—Sakel outcrosses showing Blackarm resistance were noted in Harland's RU.4 in 1936–37. Last season fourth Sakel backcrosses from these were shown to contain $\mathbf{B_2}$. It was thought that the gene **R** (reddish flowers and plant body), if transferred to Blackarm-resistant Sakels would make such strains easy to identify. Also seed admixture and outcrossing would at once be visible. Further crosses were accordingly made both in-season and out-of-season and seed lots, of the following composition, containing **R** and $\mathbf{B_2}$ are available for sowing in 1941–42 :—

$$\{[(\{[(\text{RU.4}\times\text{Sakel})\times\text{X1530A}^2[\times\text{X1730F}\}\times\text{X1730G})\times$$
$$\text{X1730H}[\times\text{X1730A}\}\times\text{X1730H}^2$$
$$\{[(\text{RU.4}\times\text{Sakel})\times\text{X1530A}^2]\times\text{X1730F}\}\times\text{N.T.2/38}^6$$
$$(\{([\text{RU.4}\times\text{Sakel})\times\text{X1530A}^2]\times\text{X1730F}\}\times\text{N.T.2/38})\times\text{N.T.66/38}^4$$

As the grandparents and sibs of grandparents of the first two of these types showed typical X1730 and N.T.2 lint on laboratory tests, these lots will be bulked individually for trial.

(vi) *Jassid Resistance : Transference of the gene* **H** *from Tanguis to Sakel strains.*—Jassids cause considerable damage to cotton in the

Northern Gezira and, in this area, probably bring about a greater cash loss than does Blackarm. An attempt is being made to check this loss by transferring the dense hairiness (**H**) of Tanguis to the leading strains of Sudan Sakel. It has been suggested that hairiness and roughness of lint are associated and the work may fail on this account.

The F_1 of Tanguis × N.T.2/38 was grown this season and crossed with N.T.2/38 and X1730H. These first Sakel backcrosses were grown in 1940 41 winter, and second backcross seed was produced for sowing next season.

Both Tanguis and the F_1 showed a fair measure of flea-beetle resistance though the resistance of the F_1 was less than that of Tanguis—a not unexpected result since hairiness is semi-dominant. No conclusions could be formed as to jassid resistance since the attack on neighbouring cottons was not severe.

(vii) *Crosses between* Sanguineum (*G. arboreum V. neglectum f. bengalensis H. and G.*) *and Sakel. Sanguineum* is completely immune to Blackarm. If this immunity should prove to be due to one factor or even to two factors, then the transference of these genes to New World types would be of great value. Crosses have, accordingly, been made between Sakel and *Sanguineum* using the latter as the female parent, but without emasculation. Pollination was done early in the morning. Bolls pollinated in this way produced a proportion of large seeds and these were assumed to be F_1. Twenty-five of these large seeds sown in 1940–41 winter produced five F_1 plants; the remainder either failed to germinate or were eaten in the cotyledon stage by insects. These five plants all showed marked Blackarm resistance, but were not immune. Following Harland's technique in putting the *arboreum* gene **R** into American Upland, it is hoped to transfer immunity to New World types.

As a second line of attack *Sanguineum* seeds were treated with colchicine to promote chromosome doubling in the hope of obtaining partially fertile *Sanguineum* × New World hybrids later. Although plants with typical outward signs of polyploidy were produced, these gave rise to no enlarged pollen grains and doubling did not appear to have occurred.

(viii) *Leaf Curl resistance.*—Since 1938–39, when X1730 strains were substituted for X1530 in the crossing programme, considerable difficulty has been encountered in hybridisation with X1730 derivatives owing to extremely severe Leaf Curl attacks on both hybrids and pure lines used as parents. These same X1730 derivatives, sown at Medani, showed marked resistance. On the other hand, N.T.2/38 is definitely resistant at Medani and this resistance is maintained at Shambat.

The susceptibility of these X1730 derivatives at Shambat has, until this season, been based on purely subjective observation. To obtain objective data, a test composed of six randomized blocks was sown on 17th August, 1940, and later examined for Leaf Curl. To avoid obscuring the issue by inclusion of plants showing only minute vein enations, only "obvious" Leaf Curl was counted. No minute examination of the undersides of leaves was made; a plant either showed Leaf Curl from above or was free. Massey's Selected Domains Sakel was used as control since this has been found highly susceptible both at Shambat and Medani.

The following results were obtained :—

Strain.	*Percentage Leaf Curl.*
X1730A	82·1
X1730F	80·9
X1730G	77·0
X1730H	80·5
N.T.2/38	33·8
M's.Sd.Doms.Sakel	60·8

In this test the differences between the X1730 strains are not statistically significant. N.T.2/38 shows significantly less Leaf Curl than either Massey's Selected Domains or the X1730 group, but the difference between Domains and X1730 types is only doubtfully significant.

It is clear from this that a strain proved to be Leaf Curl-resistant in one district cannot necessarily be relied on to be resistant elsewhere. The reasons for this are as yet unknown and deserve investigation.

(ix) *American Upland Breeding.*—A tentative start has been made on the transference of Blackarm resistance to American strains suited to the southern Sudan, but until the effects of the various resistance factors and factor combinations can be studied under the heavier rainfall conditions of the South, this programme cannot be planned with complete assurance.

Factor $\mathbf{B_3}$ is being transferred to both N.T.58/39 and 511 D, and third backcrosses of *punctatum* by these two types were made in the winter of 1940-41. Both N.T.58/39 and 511 D already show a fair measure of resistance due to $\mathbf{B_2}$ in N.T.58/39 (and probably, also, in 511 D) and the object is to increase this resistance. As a guard against accidental loss of a resistance factor, a fully susceptible American type, Durango, is also being used as a backcross parent.

(x) *Bamia* (*Hibiscus esculentus*).—The strains of bamia previously known as B.S.12 and B.S.12A have been issued in bulk under the name "Momtaza" and this variety is proving very popular with native cultivators on account of its high yielding powers, good flavour and ease of picking due to its smooth, instead of spiny, pods.

During 1940 just under three-quarters of a ton of "Momtaza" seed was produced (enough to sow 300 acres) and either sold direct to seed merchants and cultivators or supplied to the Department of Agriculture and Forests. Demand greatly exceeded supply and the variety appears to be likely to replace local types almost completely within a few years.

Summary and Conclusions.

This season Blackarm-resistant Sakel strains have been propagated in bulk for the first time. This bulked fifth backcross material was of typical N.T.2 appearance and preliminary small-scale spinning tests gave hopeful results. This material will be followed by seventh backcross strains of N.T.2 and X1730 type homozygous for resistance, seed for the propagation of which has been obtained. As an insurance, crossing has been continued to the ninth backcross.

A new Blackarm resistance factor, $\mathbf{B_3}$, has been isolated from *G. punctatum* and is being transferred both to Sakel and American cottons.

To prevent deterioration due to seed admixture and outcrossing in Blackarm-resistant Sakels the *arboreum* gene for red flowers and foliage has been incorporated in resistant strains and these are now ready for bulk propagation.

An attempt is being made to reduce jassid damage to Sakel by adding the hairiness of Tanguis to N.T.2 and X1730 types.

Momtaza bamia, a selection showing a fair measure of resistance, both to Leaf Curl and to Egyptian bollworm, has been propagated in bulk and is rapidly replacing the local crop.

Kadugli Sub-station

by
R. R. ANSON.

Introduction.

The work of breeding and testing strains to replace the existing commercial type—Pump Scheme Strain—was continued on established lines. In the varietal tests, strains 511D and N.T.63/39 were dropped out and replaced by N.T.68/39 (a derivative from Columbia strain) and Deltapine (an importation from U.S.A.).

Approval was obtained for two stores (one for seed-cotton and one for cotton seed and lint) and a gin house, and they were completed by the end of the second week in February, 1941. One standard roller gin

and one small forty-saw gin were installed. The roller gin will be used for obtaining accurate ginning outturns from small samples and for dealing with long-stapled cottons, and the saw gin will be used for larger samples. These gins will not only be valuable for the research section but will also be useful for checking up G.O.T's from various factories in this province and for dealing with odd lots which drift into the main ginnery at the end of the season and for which it is hardly worth while running the large factory.

Meteorology.

The season was quite the driest since this sub-station opened but, nevertheless, it has been, from the point of view of crop results, one of the most interesting and successful. Actual planting rains were fairly late (1st July) and there was a serious gap between mid-August and mid-September which caused considerable shedding of flowers and young bolls. On the station the total rainfall was 757 mm. but 168 mm. of this fell during May and June before any crops had been planted. Rain ceased abruptly on 6th October after which only two light drizzles were experienced, neither being worth recording. The relative humidity averaged 83·6% between the months of June and October and 36·2% for November and December. Maximum and minimum temperatures for these months averaged 92·4°-69·6° F. and 99·7°-62·3° F respectively. Conditions experienced on the sub-station were fairly general throughout the Western Jebels.

Breeding, Propagation and Testing.

Breeding and Small-Scale Propagation.—The usual breeding plot containing new selections and pedigree lines was planted and a number of promising families were selected for bulking.

Fifteen small plots containing bulkings from the previous season's breeding plot were planted on areas appropriate in size to the amount of seed available. These areas varied from 1/5th feddan* to 1 13th feddan. Sowing, done by cotton stick planters on unploughed land, was commenced and completed on 3rd July, 1940. Final yields were quite satisfactory and growth was good throughout. These small plots were planted for observation purposes and seed production, and yields obtained have no intrinsic value because, owing to soil variation, they are not comparable. In most instances they were replications of strains and sub-strains tested in the Line Tests (see later).

Nucleus Roguing Plots.—Nucleus roguing plots, to produce larger quantities of seed of strains which showed promise last season, were

* 1 Feddan=1·038 acres.

planted on areas segregated as far as possible from other cotton' Yields of seed-cotton (in kantars of 315 rotls† per feddan) and other particulars of these plots are as follows :—

*N.T.*58/39, a selection from 513 and probably a Webber outcross. Planted on Kamina Farm, Kadugli, area 3/5th feddan selfed seed, belted by 5 2/5th feddans natural seed. G.O.T. from a 100-rotl sample 30·0%. Halo length 33·9 mm. Yield from 3/5th feddan selfed=1·61 kantars. Average yield for 6 feddan area was 2·84 kantars per feddan (unploughed). A large-bolled, strong-growing strain. Shedding was rather high throughout. It gave higher yields than the control in the standard variety tests, both at Kadugli and at Talodi.

Deltapine (an importation from U.S.A.). Planted on Kadugli Main Farm, area 2·5 feddans. Moderately pure seed, twice heavily rogued. G.O.T. taken from a 100-rotl sample 38·38%. Halo length 31·9 mm. Yield per feddan 4·91 kantars (ploughed). An erect, strong-growing variety highly resistant to Blackarm, but shows little resistance to jassid. Its outstanding G.O.T., earliness and high yield, each of which have been borne out in the Standard Variety Tests both at Kadugli and at Talodi, make it appear an ideal variety for Nuba Mountain conditions. It has been arranged, therefore, that a seventy-acre increase area shall be put under this variety during the coming season and that it shall be again tested in the Standard Variety Tests at Kadugli and Talodi. Notwithstanding the fact that the lint appears slightly harsher and more highly coloured than Pump Scheme Strain, it should be more profitable even at a distinctly lower price per pound.

*N.T.*68/39, a selection from a Columbia strain. Grown on the Lagowa Experimental Farm, area 5 feddans. Moderately pure seed. (Owing to lack of transport it was not possible to rogue this area). G.O.T. taken from a 100-rotl sample 30·5%. Halo length 32·5 mm. Average yield per feddan 2·70 kantars approx. Prior to this the highest yield per feddan obtained from any variety grown on the Lagowa Experimental Farm during the past 4 seasons since it was opened, was 1·98 kantars. This high yield of N.T.68 has been maintained in the Standard Variety Tests at Kadugli and Talodi. N.T.68 is an erect, cone-shaped plant with large pointed bolls and good quality long-stapled cotton, but it does not show a high degree of resistance to Blackarm.

(NOTE.—The above tests for ginning out-turn were made from representative samples of 1st and 2nd pickings, the saw gin being left at the usual commercial setting. A sample of 100 rotls of first grade seed-cotton taken from Kadugli commercial crop of Pump Scheme Strain on the same day, gave a G.O.T. of 29·2% and a halo measurement of 31·7 mms.)

† 1 rotl=0·99 lb.

*N.T.*74/39, of the same origin as N.T.58/39 (see above). Planted at Dilling Experimental Farm, area 5 feddans. Heterogeneous and unattractive. G.O.T. from a 100-gramme sample 34·6%. Average halo length 27·6 mm. Yield per feddan 1·41 kantars. Erect, fairly strong-growing plants, but yield was greatly affected by flea beetle attack. This strain is not considered worth further trial in spite of the fact that it gave better yield than the control in the preliminary varietal test at Kadugli.

*N.T.*72/40, of the same origin as N.T.74/39 and N.T.58/39 (above). Grown near the Kamina Farm, area 1 feddan (unploughed). G.O.T. taken from a 100-grm. sample 32·5%. Average halo length 30·8 mm. weak cotton. Yield per feddan was 2·88 kantars. It did moderately well in the belt of the preliminary varietal tests at Kadugli, but it is not an outstanding strain.

*N.T.*83/39, a sub-strain of Deltapine. Grown at Kalogi on sloping land of medium quality, area 1 feddan. Moderately pure seed. G.O.T. taken from a 100-grm. sample 39·0%. Halo length 29·8 mm. Yield per feddan 2·30 kantars approx. This area was grown by a native cultivator. It had been damaged by cattle and carelessly picked. It is estimated that roughly $\frac{2}{3}$ kantar has been lost through neglect. It does not show much resistance to jassid.

Large Scale Propagation.—At Damgamad, near Talodi, an agricultural "investigation" area of the Department of Agriculture, consisting of 67 feddans on various types of soil and given various treatments (some ploughed, some unploughed) was planted with *N.T.*43/37 (U.4×Gambia 14)×U.4, as a first increase area of this strain. Owing to a shortage of seed, sowing was not commenced until rains had really set in. This meant that it was sown somewhat later than had been the case during the previous season with Pump Scheme Strain, when, had the first sowing failed or partially failed, ample seed for re-supplying was available. A good stand was obtained, and in spite of the later sowing, together with a much less favourable season, the ultimate yield averaged 2·12 kantars per feddan, which is an increase of 0·03 kantar per feddan over Pump Scheme Strain grown in the season before. This may be regarded as satisfactory. Eight commercial bales of lint from the above variety were sent for valuation and brokers' comments. In their report the brokers stated that in their opinion N.T.43 cotton is a considerable improvement on N.M.T. and N.M.K. cottons (viz., Nuba Mountains Pump Scheme Strain). This is also quite satisfactory, so far as it goes.* N.T.43/37 shows some resistance to

* The results of brokers' examination of *small* samples from previous seasons' *varietal tests* have not been quite so encouraging, but it seems likely that the lint of N.T.43 is at least not markedly *inferior* in handling properties.

Blackarm and jassid but it has rather small bolls and is a little later than Pump Scheme Strain. In ginning outturn it shows a slight improvement.

It is hoped that this strain will be improved upon by some of the newer ones which at present look more promising in yield and G.O.T., but in the meantime a second increase area of 700 feddans with a nucleus of 70 feddans of special seed has been arranged for the coming season.

Line Test.—Table VIII below gives the results of a small-scale preliminary yield test in which new sub-strains, bulked from last season's breeding plot, were tested in single lines with controls of Pump Scheme Strain on either side. The yields of seed-cotton are given as a percentage of the average yield of the two adjacent controls in each case. The other data are from samples of 100 bolls.

TABLE VIII.
DATA FROM COTTON LINE TEST, KADUGLI.

Strain Symbol.	*Origin.*	*Seed-cotton Yield.*	*Seed-cotton per Boll. gms.*	*G.O.T. %*	*Lint Index. gms.*	*Halo Length. mms.*
N.T.96/40 ...	57 × Over-the-Top ...	119	5·86	34·0	5·6	32·0
N.T.88/40 ...	ex Acala	118	6·45	34·0	6·7	29·2
N.T.91/40 ...	U.4 × Camb. × U.4 ...	117	5·40	32·0	5·5	35·5
N.T.74/40 ...	513 outcross	117	5·00	32·5	4·8	32·5
N.T.15/40 ...	U.4 × Camb. × U.4 ...	113	4·98	34·5	5·5	33·0
N.T.90/40 ...	U.4. × Camb. × U.4 ...	112	5·26	31·5	5·3	33·7
N.T.93/40 ...	U.4 × Camb. × Jam. Xero	112	4·29	30·5	4·8	35·9
N.T.94/40 ...	U.4 × Jam. Xero. × U.4	105	4·88	34·0	5·9	34·1
Control† ...	Pump Scheme Strain ...	104§	4·30	30·5	4·6	32·5
N.T.92/40 ...	U.4 × Camb. × Jam.Xero.	103	4·83	33·0	5·1	34·1
N.T.87/40 ...	513 outcross	93	4·48	32·5	5·5	33·6
511 F ...	511 substrain	87	3·78	34·5	5·4	30·4
N.T.89/40 ...	ex Durango	83	5·38	34·0	5·4	31·6
N.T.84/39 ...	ex Ug. S.P. 102 ...	81	5·47	32·5	5·6	34·5
N.T.95/40 ...	U.4 × Over-the-Top ...	79§	4·77	34·5	5·0	31·4
S.P.102 ...	Imported from Uganda	73	5·09	31·5	5·2	34·5

† Bulk stock of local commercial variety. § Influenced by outside row effect.

Preliminary Varietal Test, Kadugli.—Five strains were replicated five times on unploughed land. The final stand was good and in no instance did it go below 95%. The land was rather low-lying and inclined to be swampy but it was fairly uniform throughout for this characteristic. N.T.58/39 was the earliest strain (and gave significantly higher yield) and N.T.78/39 the latest to reach maturity. Detailed results are given in Table IX below :—

TABLE IX.
YIELDS OF PRELIMINARY VARIETAL TEST, KADUGLI.

Strain.	*Seed-cotton.*		*G.O.T. %*	*Lint.*	
	*Kts. per fed.**	*% Control.*		*Rotls per feddan.*	*% Control.*
N.T.58/39 (513 outcross)	1·78	137	29·7	167	147
N.T.74/39 (513 outcross)	1·56	120	30·6	150	131
N.T.69/39 (see below)	1·54	118	27·4	133	116
N.T.78/39 (Seln. from Pump Scheme) ...	1·39	107	27·0	118	103
Pump Scheme Strain (Local)	1·30	100	27·9	114	100
S.E.	±0·06	±4·6	—	(±5·3)	(±4·7)

The S.E. was obtained from analysis of the seed-cotton yields.
Differences of 14 in the 3rd column are significant at P=0·05.
N.T.69/39 is a U.4 × Cambodia × Jamaica Xerophytic hybrid. Pump Scheme Strain was regarded as the control variety.

* Kts. per fed.=Kantars of 315 rotls per feddan (1 rotl=0·99 lb., 1 feddan=1.038 acres).

Standard Varietal Tests.—In the Standard Varietal Tests at Kadugli and Talodi (one being a replication of the other) Deltapine, a variety introduced from America two years ago, did by far the best and maintained the phenomenonally high ginning percentage and high yield which it had previously displayed in unreplicated trials.

N.T.43/37 which, owing to shortage of seed, had to be planted from that obtained from 4th and 5th pickings, germinated badly and was, therefore, handicapped considerably on this account. The two tests gave closely similar results as will be seen from Tables X and XI below :

TABLE X.

YIELDS OF STANDARD VARIETAL TEST, KADUGLI.

Strain.	*Seed-cotton.*		*G.O.T.* %	*Lint.*	
	Kts. per fed.	% *Control.*		*Rotls per feddan.*	% *Control.*
Deltapine (imported from U.S.A.) ...	3·89	130	38·2	468	172
N.T.68/39 (a Columbia 44 derivative) ...	3·47	116	30·3	332	122
N.T. 58/39 (513 outcross)	3·26	109	29·8	307	113
Pump Scheme Strain (local)	2·99	100	28·8	272	100
N.T.43/37 (U.4 × Cambodia × U.4) ...	2·70	90	29·0	247	91
S.E.	±0·11	±3·6	—	(±10·6	(±3·9)

The S.E. was obtained from analysis of the seed-cotton yields.
At P = 0·05 differences of 11 in the 3rd column are significant.

TABLE XI.

YIELDS OF STANDARD VARIETAL TEST, TALODI.

Strain.	*Seed-cotton.*		*G.O.T.* %	*Lint.*	
	Kts. per feddan.	% *Control.*		*Rotls per feddan.*	% *Control.*
Deltapine (see above)	3·57	125	38·3	431	166
N.T.68/39 ,, ...	3·02	106	29·8	284	110
N.T.58/39 ,, ...	2·96	104	30·1	281	109
Pump Scheme ,, ...	2·85	100	28·8	259	100
N.T.43/37 ,, ...	2·72	95	29·8	256	99
S.E.	±0·09	±3·1	—	(±8·7)	(±3·4)

The S.E. was obtained by analysis of the seed-cotton yields.
At P = 0·05 differences of 9 in the 3rd column are significant.

Gap Filling. –In past years it had been noticed that when gaps in the cotton plots due to various causes, were planted by seed, the resultant seedlings never managed to catch up in yielding capacity with those produced from the original sowing. In order to overcome this it was decided to experiment with a new technique ; this consisted of planting seed in bottomless tin cylinders 4″ × 6″ on the same day as the Varietal Test was planted. Three seeds were planted in each cylinder and some 400 cylinders were planted up with each variety. In this way all seedlings got exactly the same start. Gaps were filled some ten to fifteen days after planting when seedlings had well passed the cotyledon stage. Suitable weather was chosen for this and suitable holes being dug, the cylinders were quickly immersed into a bucket of water, placed in the hole, tin and all, the tin cylinder was then gently

drawn up leaving the earth containing the seedlings in its allotted place. In this way after a few days it was not possible to distinguish between the original crop and the re-supplied seedlings and the whole process was both simple and satisfactory.

Pests and Diseases.

Termites were less severe than in previous seasons and jassid did not appear until late in the season when its effect was negligible.

With the exception of some low-lying places on some portions on Kamina farm, Blackarm was not severe.

Conclusions.

With the exception of N.T.43/37 which owing to bad seed had to be re-supplied many times before a satisfactory commercial germination could be obtained and was naturally heavily handicapped on this account, all strains tested in the Nuba Mountains varietal trials showed some improvement over the control.

Deltapine stood out well above the other strains in yield of lint per feddan. It is, however, rather a harsh cotton and we have yet to see what brokers' and spinners' opinions will be of the lint.

Cotton Varietal Testing in Equatoria

by

H. E. KING.

This season the sites of the test plots on the east bank of the Nile were changed from Opari and Kerripi to the Luluba Hills locality 50 miles to the north-east.

Rainfall was extremely light and irregular, only 480 mms. fell at the Lomeigo plot and 722 mms. at Odimo during the growing season. Nevertheless the growth was quite good and very fair yields were obtained at both sites.

To the west of the Nile, in addition to the usual test on the experimental farm at Maridi, a second test was sited 15 miles to the west of this at Onga.

In this locality also rainfall was low, particularly towards the end of the season, but high yields were obtained.

Of the varieties tested, X.A.129 (which is the main crop variety east of the Nile) is a selection from Pump Scheme Strain ; 511 D (the commercial crop in Maridi locality) and 511 E are substrains bred from Uganda S.G.85, while the remaining three strains, S.P.20, S.P.84 and

S.P.102 were imported from Uganda. These latter proved distinctly earlier cropping than the Sudan-bred strains, but not superior in final yield. S.P.20 and S.P.84 showed markedly more jassid damage than the other strains in the Maridi tests. The ginning outturns of S.P.20 and S.P.84, although rather higher than the local types, were well below those recorded for these strains in Uganda.

The yields obtained were as follows :—

TABLE XII.
LULUBA HILLS (LOMEIGO AND ODIMO).

Strain.	*Seed-cotton (K.p.f.).*			*G.O.T.*	*Lint.*	
	Lomeigo.	*Odimo.*	*Both Plots together.*		*Rotls per fed.*	*% of 511 D.*
S.P.20	1·75	1·82	1·79	31·7	178	102
X.A.129	1·87	1·82	1·85	30·4	177	101
511 D	1·77	2·06	1·91	29·0	175	100
S.P.84	1·67	1·72	1·70	32·1	172	98
S.P.102	1·63	1·85	1·74	29·3	161	92
S.E.	±0·08	±0·06	±0·05	—	(±4·8)	(±2·74)

The statistical anlysis was carried out on the seed-cotton yields, varietal variance was significant at P=0·05 at Odimo and for the two sites when analysed together.

TABLE XIII.
MARIDI LOCALITY (MARIDI FARM AND ONGA).

Strain.	*Seed-cotton (K.p.f.).*			*G.O.T.*	*Lint.*	
	Maridi Farm.	*Onga.*	*Both Plots together.*		*Rotls per fed.*	*% of 511 D.*
511 E	2·78	2·78	2·78	31·0	272	106
S.P.84	2·41	2·77	2·59	32·8	268	104
S.P.20	2·40	2·82	2·61	32·1	263	102
511 D	2·44	2·86	2·65	30·7	257	100
S.P.102	2·31	2·66	2·49	29·4	230	89
S.E.	±0·10	±0·06	±0·06	—	(±12·4)	(±4·82)

The statistical analysis was carried out on the seed-cotton yields, varietal variance was significant at Maridi Farm and for the two sites together.

G.O.T's at Luluba Hills are based on ginning whole crop of both plots. At Maridi, on ginning of Maridi Farm plot only. (Samples only from Onga were ginned. These showed closely similar varietal differences.)

PROGRAMME OF WORK OF THE PLANT BREEDING SECTION, SEASON 1941-42.

Work is being continued on the same general lines as in 1940/41 season at each station.

At Shambat, in addition to bulking up seventh backcross material, ninth backcrosses are being grown in the Sakel×Ug.B.31 series and work on other Sakel backcrosses is proceeding.

Increased attention is being paid to the problem of improving the resistance to Blackarm of American Upland cotton varieties for rain-growth. The possibility of adding the factor $\mathbf{B_3}$ to types already containing $\mathbf{B_2}$ is being investigated, and the addition of both $\mathbf{B_2}$ and $\mathbf{B_3}$ to

susceptible, but otherwise useful types has been commenced. Uganda S.P.84R, 511 D, X.A.129 and Deltapine, are included in this work.

At the Gezira Research Farm, the search for improved substrains of X1730 and N.T.2 derivation is being continued with a more elaborate technique. New selections of Sakel type are also under test. The inheritance of resistance to Leaf Curl is being investigated. Extensive field trials to include Blackarm-resistant backcross material from Shambat have been arranged.

All available types of Sorghum are undergoing careful trial.

At Kadugli, in addition to normal pedigree line breeding work, field trials and propagation of promising strains are continuing. Both N.T.43/37 and Deltapine are being propagated in bulk simultaneously with further replicated trials in comparison with Pump Scheme Strain.

In Equatoria, the strains tested in 1940–41 are being tried again with the addition of Deltapine. The number of separate sites in this series of experiments has been increased from four to six and a range of sowing dates and cultural treatments superimposed on the randomized blocks of the varieties at each site.

[*Included by courtesy of the Uganda Government.*]

UGANDA

COTTON EXPERIMENT STATIONS, KAWANDA AND SERERE, PROGRESS REPORTS FOR THE SEASON 1940-41

Introductory Note

BY

G. W. NYE

Acting Director of Agriculture.

At the Conference held in London on cotton-growing problems in September, 1938, a discussion took place on the relative merits of mixtures and pure strains. Reference was made to the deterioration of varieties of cotton after they have been put into distribution. One relatively pure variety in Uganda has maintained a high degree of purity for nine years in a geographically isolated district without obvious signs of deterioration. The same variety in an area exposed to a large measure of admixture has changed out of all knowledge in eight years and had to be replaced. The older mixed types have held out much longer, but are now after fourteen years beginning to show signs of decline. Here again the prime cause appears to be admixture, particularly where the adulterant type contains a proportion of black (strictly " fuzzy tip ") seed. It may be that mixtures, for which there is a good deal to be said, can be stabilised with success, but there are strong indications that the recessive " fuzzy " character must be preserved from contamination with black seeds.

There is further evidence that comparatively highly-bred varieties such as B.P.52 and S.P.84 do deteriorate, or at least settle down, quite early on in their career. In the Report on Kawanda it will be seen that trials are being made of two mixtures. The better one, X3, is a mixture of B.P.52, with good staple and spinning quality, and B.181, which is high-yielding and resistant to disease. But we do not know how long they will take to become stable, neither do we know what the effect will be of mixing two contrasting strains. Environment as well as open pollination must play a considerable part. For instance, this mixture, in which B.P.52 predominated originally, has in three years

become very like B.181. Presumably B.P.52, which is susceptible to Blackarm, will in a Blackarm year recede in favour of B.181. The hybrid between B.P.52 and B.181 favours B.181, so that open pollination is also likely to make this type more evident. Mixtures are intended to be an insurance against seasonal fluctuations, but we do not yet know enough about them to be certain that their distribution at early stages will not result in early deterioration.

The progress of cotton breeding in Uganda has come face to face with the same questions as are being asked elsewhere in the world. Nevertheless, we do know that certain flexible types have served us well, and we have in reserve other varieties which are definitely resistant to Blackarm, wilt and jassid. We can also improve on the present quality of ginning out-turn of the commercial crop. The problem of combining several of these characters, many of them antagonistic, remains as one of the main objects of our long-range breeding investigations. In the meantime the matter is one largely of expediency, and in order to ensure the seed supply a five-year distribution scheme has been drawn up for each province whereby the seed in each area is completely renewed every five years even if no new variety is available.

In the season under review the total crop was approximately 370,000 bales, which was very satisfactory considering the difficult weather conditions experienced in the planting months and shortly after. The drive for improved methods of cultivation is bearing fruit ; cotton planted up and down the slope is now far less commonly seen. Improvement in spacing is also most encouraging and will have contributed its effect to the yields of last season. Early planting, difficult in many areas, is gradually being accepted by cultivators as a desirable objective. Cultural and manurial experiments are being continued at Kawanda and Serere and are providing valuable information. They are assuming relatively greater importance against the background of the variety question. Experiments testing the relative merits of farmyard manure, cotton seed, cotton seed meal and cotton seed ash are building up a wealth of information, not only on yield but on quality and ginning out-turn.

The relation which the cotton crop bears to the economy of Uganda is well known and it is of importance that we should experiment in every direction with the object of increasing production per acre rather than increasing the acreage under cultivation. There are still some areas in Uganda capable of expansion without detriment to the soil, but in the main cotton-growing areas expansion of acreage is almost certainly undesirable and it is cultivation which must be improved.

Experiments in the maintenance of soil fertility now occupy a prominent place and we advocate a basis of 3 years' rest under grass after 3 years' cultivation wherever possible. Where this is not possible, manuring is even more important, and investigations into the uses of cattle manure, grazing, and cotton seed manures are in progress at Kawanda and Serere and other centres where rural development projects are established.

KAWANDA ZONE.

BY

H. R. HOSKING.

Introduction.

The season was again dry, but it is probable that we must re-adjust our ideas as to what constitutes an average season's rainfall at Kawanda. Good yields were obtained from early sowings: hail storms on three occasions damaged the cotton and made it impossible to compare satisfactorily the growth habits of the various strains and selections.

Meteorology.

Once again rainfall was spasmodic during May and June. Records for five seasons at Kawanda are now available :—

	Mean monthly rainfall, in inches, for 5 years, 1936–40.	1936–40.		1940 *Rainfall.*
		Highest.	Lowest.	
January	2·38	6·61	0·29	1·89
February	3·01	5·39	0·35	5·10
March	3·77	6·03	1·57	6·03
April	7·42	9·99	5·39	5·89
May...	4·84	9·03	1·92	3·63
June	2·51	3·55	1·86	1·98
July...	2·05	3·14	1·12	2·21
August	2·73	4·17	1·49	2·41
September	4·48	8·74	1·44	1·44
October	4·76	7·35	3·48	3·74
November	5·19	8·49	1·94	8·49
December	3·53	7·99	1·83	2·12
TOTAL	46·67	—	—	44·93

From the first column of the above table it will be seen that the average expectation of rain for the three months of June, July and August is only 2·43 inches per month. It will also be seen that our distribution is markedly bi-modal; the second dry trough occurs in the second half of the planting season and makes it very difficult to obtain good stands after May. Late planting in August and early September, on the other hand, is usually successful.

The heavy November rainfall of 8·49 inches in 1940 was associated with hail storms.

Cotton Genetics and Breeding.

The Breeding Plot consisted of a number of re-selections from B.181, a large number of new introductions from various countries, and a number of field selections from B.P.52 and Buganda Local. In addition, a large part of the plot was consigned to crosses and back-crosses between B.181 and B.P.52. Once again the back-cross B.181 × (B.181 × B.P.52) proved successful: it would seem, however, that the shorter and harsher lint of B.181 is dominant over the long silky lint of B.P.52 in all simple crosses between these two strains, and doubling the B.181 makes the back-crosses indistinguishable from B.181 in respect to lint characters. Of the new introductions the best from the disease point of view were Mexican Big Boll (good for Blackarm but poor for wilt), E.36.7, E.38.2, Missdel 1,0539, Missdel 1 W.R., Missdel 4.7.2, and 511 C.D. and E.

Of the newly introduced perennials, *G. hirsutum var. religiosum* (Gambia Native) from Shambat is outstanding for resistance to Blackarm disease: crosses were made between this and our three standard families B.P.50, B.P.52 and B.181.

One field selection from B.P.52 appeared to be much more resistant to Blackarm than bulk B.P.52.

The incidence of wilt was very sporadic and this made it difficult to draw conclusions as to the relative susceptibility of the different strains.

The B.181 re-selections showed up very well for resistance to Blackarm and apparent freedom from wilt, but no improvement in staple could be found.

Variety Trials.—The main variety trial at Kawanda was again in the form of a 7 × 7 Latin Square. It was sown at a spacing of 3′ × 1′ on June 29th, 1940.

Variety.	*Original germination.* %	*Percentage Angular Leaf Spot. Oct., 1940.*	*Blackarm Lesions per plant.*	*Wilt % plants infected.* *Ext.* *Int.*	*Yield Seed Cotton. lb. per acre.*	*G.O.T.* %
Local	53·0	9·5	2·36	71·0	1235·2	30·0
B.P.52	44·7	37·1	4·94	52·6	1014·3	31·6
B.181	73·2	0·4	0·10	39·0	1554·7	32·9
X	72·7	46·5	3·03	56·1	1178·2	32·2
X3.38	57·2	1·9	0·60	59·9	1333·8	32·7
X3.39	73·9	15·4	1·25	48·9	1399·1	31·9
N17.M.2	67·2	23·6	2·95	70·3	1212·4	31·1
L.S.D.	14·8	6·7	0·82	15·9	137·9	0·5

Note.—B.181 is a selection from Local.
X is a mixture of S.G.23.8, B.P.52 and B.P.79.
X3 is a mixture of B.P.52 and B.181.
N17.M.2 is a mass-selected Busoga N 17 population.
X3.38 was two-years-old seed and this resulted in a reduction of primary Blackarm infection.

It is disappointing to find that B.P.52 gave a significantly lower yield than all other varieties. On the other hand B.181 has again given a good yield and shown high resistance to Blackarm and wilt.

There is a very high correlation between yield and Blackarm disease and once again a fairly high correlation between wilt and yield.

District Variety Trials.—4×4 Latin Squares containing Local (seed from the nearest ginnery), X3, B.P.52 and B.181 were laid down at nine centres scattered over Buganda.

RESULTS.

YIELDS OF SEED COTTON PER ACRE EXPRESSED AS A PERCENTAGE OF LOCAL.

	Local.	*B.P.52.*	*B.181.*	*X3.*	*L.S.D.*	*Mean yield of the centres in lb. of seed cotton per acre.*
Kyanamukaka ...	100	80·8	79·2	88·4	—	1404·9
Kalungu	100	76·6	97·6	78·3	—	622·8
Nkozi	100	89·8	91·9	90·0	—	1298·9
Kabasanda ...	100	96·6	100·4	100·8	—	1985·6
Bukomero... ...	100	97·8	105·2	105·1	—	1650·5
Bukalasa	100	67·8	113·5	112·5	24·3	1109·9
Kalagala	100	105·9	134·3	111·4	20·2	1103·4
Nakifuma... ...	100	92·5	94·6	99·2	—	807·2
Mukono	100	80·1	90·7	88·6	—	1547·1
Means of all centres	100	88·1	97·2	99·2	—	1281·1

Using the chi-squared test on the total variance of each centre it was found that a combined analysis of variance for yield was not permissible on account of the very high total variances of the trials at Kyanamukaka, Bukalasa, Kalagala and Mukono. Grouping the trials according to their total variances, it was found that significance was obtained only by combining the three centres, Bukalasa, Kalagala and Mukono, and that in this group B.P.52 gave a significantly lower yield than the other three varieties. This result corresponds with that obtained in the Kawanda trial. Furthermore one cannot ignore a mean yield of 12% less than Local over all trials. It can be concluded therefore that in the 1940–41 season B.P.52 has given a lower yield of seed cotton than Local : against this can be set off to a certain extent better ginning percentage and much better lint quality. In fact, B.P.52 lint fetched a premium over Local. A sample of seed cotton from each plot of each trial was ginned. The mean ginning percentages of the four varieties over all trials in 1940–41 was :—

Local	29·5%
B.P.52	31·5%
B.181	32·3%
X3	31·7%
Least significant difference	0·3%

Blackarm observations were made early in December, 1940, with the following results :—

Mean Blackarm lesions per plant over all centres :

Local	2·58
B.P.52	2·33
B.181	0·50
X3	1·85

B.181 being significantly better than the other varieties over all centres.

There was a highly significant interaction between variety and centre, due to the irregular behaviour of Local relative to the other varieties. This can be explained by the variation of Local from place to place.

Investigation on the different seed types which constitute Buganda Local.—A sample of seed was drawn from a nearby ginnery (Kawempe) and this was sorted into eight seed types.

A small trial was planted in August in a randomised block layout with six replications.

Characters of the Parent Types.

Seed Type.	*Weight of of 100 seeds. grms.*	*Percentage number of seeds of the various types.*	
Very heavy white fuzz	11·38	7·30	13·26
Heavy white fuzz	10·86	5·96	
Normal white fuzz	10·97	11·84	25·09
Sparse white fuzz	10·96	13·25	
Green fuzz	10·87	1·37	
Half naked white fuzz	10·97	15·72	
Naked with white tuft	10·48	44·42	
Naked with green tuft	10·68	0·14	

Significant differences between the progeny of the eight types were found to exist in the following characters :—

Seed Type.	*Germination % Angular Transformation.*	*Ginning Percentage.*	*Lint Length. mm.*
Very heavy white fuzz	54·9	32·8	27·5
Heavy white fuzz	52·4	32·4	27·7
Normal white fuzz	55·9	32·4	28·4
Sparse white fuzz	55·5	32·4	26·8
Green fuzz	50·9	31·7	27·9
Half naked white fuzz	61·3	32·6	28·2
Naked with white tuft	61·8	31·2	27·2
Naked with green tuft	62·3	31·4	28·3
Least significant difference	8·4	1·0	1·2

From the above it can be seen that :—(1) the naked or semi-naked types give better germination than " Heavy white fuzz " and " Green Fuzz " ; (2) the ginning percentages make two groups, *i.e.*, the " White fuzzed " and " Half naked " having higher ginning percentages than " Green fuzz " and the two naked and tufted types ; and (3) in lint length " Normal white fuzz " gives significantly longer lint than either " Naked with white tuft " or " Sparse white fuzz."

Observations on incidence of angular leaf spot, Blackarm, and wilt diseases, and on yield of seed cotton were also made, but were statistically inconclusive. Apart from yield—to which no statistical significance can be attached—" Normal white fuzz " appears the best all-round type. It has the best lint both for length and character, and was good for

diseases and ginning percentage, but only fairly good for germination. Its lint character was outstanding.

Although no completely naked seeds were sorted out from the original seed sample, the progeny of the type " Naked with white tuft " showed a number of this type. These " completely naked " seeded plants gave a mean lint length of 29·4 mm. and a ginning percentage of only 25·0%.

The following table shows how the eight types bred out. It was not found possible to discriminate between " Very heavy " and " Heavy white fuzz " or between " Normal white " and " Sparse white fuzz " when small quantities of seed (the produce of single plants) were compared.

Percentage distribution of parental types.	*Percentage Distribution of Progeny.*						
	Heavy white.	*Normal white.*	*Green.*	*Half naked.*	*Naked white tuft.*	*Naked green tuft.*	*Completely naked.*
Very heavy white ...	44·5	30·0	1·1	10·0	14·4	—	—
Heavy white ...	27·9	45·3	1·2	12·8	12·8	—	—
Normal white ...	24·4	47·8	1·1	15·6	11·1	—	—
Sparse white ...	11·6	49·4	3·2	22·1	10·5	3·2	—
Green	1·3	17·9	48·7	16·7	10·3	5·1	—
Half naked	3·3	16·3	3·3	29·3	44·5	2·2	1·1
Naked white tuft ...	1·8	4·5	1·8	10·7	74·9	—	6·3
Naked green tuft ...	1·0	4·9	6·9	8·8	58·8	18·6	1·0

Most of the parental types bred fairly true for seed type, but it is noticeable that the progeny of " Half naked " were predominantly " Naked with white tuft " and the progeny of " Naked with green tuft " were predominantly " Naked with white tuft." It would seem that these two types are either very recessive or else are unfixable heterozygous phenotypes.

A further interesting point arises. Although the original seed sample contained varying proportions of the eight seed types, it was found that by planting equal proportions of these eight bred types the resulting progeny differed little from the original population.

	Very heavy white.	*Heavy white.*	*Normal white.*	*Sparse white.*	*Green.*	*Half naked.*	*Naked white tuft.*	*Naked green tuft.*	*Completely naked.*
Percentage distribution of the parent population	7·30	5·96	11·84	13·25	1·37	15·72	44·42	0·14	—
	13·26		25·09						
Percentage distribution of the progeny resulting from planting equal amounts of the eight parental types	13·96		26·17		7·52	15·57	31·81	3·76	1·21

Conclusions.

1. Buganda Local seed is predominantly " Half naked with white fuzz " and " Naked with white tuft."

2. The type termed here " Normal white fuzz " appears to be the most desirable seed type in the mixture constituting modern Buganda Local.

3. Low ginning percentage is associated with the " Half-naked," " Naked with white tuft," and " Completely naked " seed types. The latter have a very low ginning out-turn.

4. Selecting out " Normal white fuzz " and selfing until it breeds true should give a strain with superior lint—both in length and character—and with better ginning percentage than present-day Buganda Local. This will be attempted in the coming seasons.

5. It is not yet known whether a pure breeding " Normal white fuzzed" population will yield as well as the mixture known as Buganda Local.

6. The predominant type (*i.e.*, " Naked with white tuft ") which constitutes Buganda Local has a significantly lower ginning percentage than the white fuzzed types.

Kawanda Seed Farm and Segregated Area.

A mixture of B.P.52 and B.181, known as X3.38, was planted over these areas.

The total acreage planted was 284·1 but only 227 were harvested. The total crop produced was 161,007 lb. of first quality seed cotton and 4,785 lb. stained, giving an average yield per acre of 730 lb. seed cotton. (In the previous season B.P.52 gave an average yield of 746 lb. of seed cotton in the same area.) The crop experienced dry weather, and about 10% of the plots planted were sadly neglected. A total of 51,512 lb. of first quality lint was produced. This fetched Shs.-/54 per lb. lint : the ginning percentage of first grade averaged 32·0% over the whole crop. Heavy seeds with less lint resulted from the bad weather conditions during boll ripening, with consequent lowering of the ginning percentage.

Spinning Tests.

Samples from 1939–40 were submitted to the Shirley Institute, Didsbury, and to the Technological Laboratory of the Indian Central Cotton Committee. The Shirley report can be summarised as follows :— B.P. 52 again gave the strongest yarns of all the samples submitted, but the yarn appearance was poor compared with those from Buganda Local B.181 and X3.38.

The Indian Central Cotton Committee report stated : " X3.38 gave the best spinning performance, B.P.52 and B.181 came next in order, while Buganda Local took last place : Buganda Local and B.P.52 show a decline as compared with their results of 1938–39. B.181 alone has maintained its performance of last season."

Entomology.

Lygus was again present, but no serious damage resulted. In the dry season (January and February, 1941,) jassids appeared in fairly large numbers on the collection of perennial cottons and severely damaged some of the plants.

Mycology.

Again interest centred on Blackarm disease and *Verticillium* wilt. Following severe hail storms, Blackarm infection was on the whole higher than usual. The sporadic appearance of wilt in all plots makes it extremely difficult to assess varietal differences. A new technique was evolved by the Senior Plant Pathologist to ensure even infection of wilt. Seed was germinated, the young seedling was uprooted before any root hairs had developed and was then dipped in a liquid culture of *verticillium*. The seedlings were then transplanted into banana fibre pots. When established, the bottoms of the pots were cut away, and the whole planted out in the field.

Of a number of varieties subjected to this treatment the U.S.A. strain Delfos 4 was outstanding for resistance. B.P.50 again proved to be very susceptible.

Summary.

The second half of the planting season was again very dry : this was followed by heavy rain associated with hail storms in November, 1940.

B.P.52 gave 18% lower yield of seed cotton than Local at Kawanda, and 12% lower yield in the nine district variety trials scattered over Buganda.

There is evidence that B.P.52 has deteriorated in yield as compared with Local during the last six seasons.

An analysis of the various seed types which constitute Buganda Local gave very interesting results and has suggested a valuable line for future work. It was proved that " black " seeded plants have lower ginning percentages than white-fuzzed seeded plants.

The Kawanda Segregated Area gave a yield of seed cotton of 730 lb. per acre compared with 746 lb. in the previous season. Spinning tests

on the 1939–40 crop samples again showed that B.P.52 produces strong carded yarns which are poor in appearance.

A new technique for ensuring even infection of *Verticillium* wilt was tried out by the Senior Plant Pathologist with promising results.

EXPERIMENTAL PROGRAMME FOR THE SEASON 1941-42.

Agriculture.

Interplanting of Cotton : Preliminary observations to be made on cotton interplanted with groundnuts, beans, soya beans and tepary beans.

Cotton Genetics and Breeding.

Selection Work.—Eight randomised trials with small plots to be laid down in the Breeding Plot. All plants to be inoculated with *Verticillium* wilt and sprayed with Blackarm disease organism. Trials divided according to families or source of seed, *e.g.*, B.181, B.P.50, B.P.52, U.S.A., Trinidad, Sudan, simple crosses of B.P.52×B.181, and back-crosses of B.P.52×B.181.

Crosses.—A series of crosses made in 1940–41 between newly introduced varieties from other countries and the three main families B.P.50, B.P.52 and B.181, to be back-crossed with the appropriate Uganda strains : also to be sprayed with Blackarm.

New Introductions.—Seed recently received from other countries to be planted for observation.

Perennials.—Planted in 1940. To carry on.

Variety Trials.

(i) *Kawanda.* (*a*) Nine varieties to be laid down in 18 incompleted blocks.

(*b*) Trial of local seed unpicked-over *versus* local white fuzz and local black seeds.

(*c*) Miniature replication of (*a*) to be sprayed with Blackarm to determine effect of acute attack of this disease on yield.

(ii) *District Trials.*—4 ×4 Latin Square at 10 centres as in the previous season. Varieties : Local, B.P.52 ; B.181 and X3.

Increase.

Kawanda. (*a*) Six $\frac{1}{4}$-acre plots of Ntanzi white fuzzed seed, Delfos 4 wilt-free material, B.P.213, X4, X5 and B.C.7.12.

(*b*) 1 acre of B.P.50, S.6 from Serere and 2 acres of original B.181 seed.

(*c*) 20 acres of B.P.52 grown at Bukalasa in the previous season.

(*d*) About 200 acres of B.P.52 to be grown on the Kawanda Segregated Area by native cultivators.

Districts. (*a*) About 6,000 acres of B.P.52 in Bugerere County.

(*b*) About 100,000 acres in Kyagwe and Kyadondo counties, and in the southern parts of Bulemezi county.

SERERE ZONE.

BY

J. D. JAMESON.

Introduction.

This was the first completed season since the building of the new Serere laboratory and the staff reorganization which followed. The cotton programme was given fuller expression in all its aspects.

Meteorology.

The total rainfall in 1940 was 57·34″, the average for 19 years being 53·51″. Rain was well distributed, but the second rains were late. The result was an all time record cotton crop in the immediate neighbourhood of Serere, late plantings yielding very much better than is usual in relation to early plantings.

Agriculture.

Manurial Trial.—An early crop of *Eleusine* failed, and the subsequent crop of cotton was a very poor one for the season. The plots with farmyard manure yielded more than twice as much as the control plots, but it must be concluded that we have not succeeded in this experiment in maintaining fertility with heavy dressings of farmyard manure. This does not mean that it is proved that fertility cannot be maintained with farmyard manure at Serere. Blackarm was again more prevalent on the plots treated with lime. Seed weight and lint index were again increased by farmyard manure, but this year ginning percentage was not reduced. Seed taken from the five treatments of the previous crop (between which there were big differences in seed weight) produced plants that were indistinguishable in all respects except that the seed weights stood again in the same order.

Cotton Seed and Meal Manurial Trial.—Blackarm again decreased with increasing levels of manure. Yield was again increased, meal producing a bigger response than crude seed. Seed weight and lint index were increased, and ginning percentage reduced. The subsequent crop of *Eleusine* again gave very large responses to residual effects.

Cotton Seed and Ash Manurial Trial.—This experiment was started because ash is so much cheaper to transport. Dressings were balanced on the assumption that a unit of seed yields $7\frac{1}{4}\%$ of ash. Blackarm was decreased by manuring, more so with seed than with ash. The land was in good heart to start with and manuring with seed made the plants so woody that yield was actually decreased. Ash increased yield slightly.

Fertility Experiment.—Yield responded to both $2\frac{1}{2}$ and 5 tons of farmyard manure, but no differences in Blackarm or ginning percentage were detected.

Interplanting Experiment.—It was finally concluded that the interplanting of cotton with groundnuts, though in some seasons and under certain systems successful, cannot be recommended for general practice in the Serere area.

Plants per Hole.—There was a fresh indication that two plants per hole are better than one.

Gap-filling.—A preliminary experiment closely confirmed the results obtained at Barberton, particularly as regards the check caused to original plants by gap-filling (proved by measurements of plant height).

Uniformity Trial.—The case for long narrow plots was abundantly confirmed under Serere conditions, not only for yield, but for Blackarm and *Lygus* observations.

Genetics and Breeding.

Selection Plots.—These were organized as in the previous season. This arrangement and a year of high yields combined to give very satisfactory quantities of seed. The main objectives were :—

(*a*) Plants setting a good main crop ; this implies, amongst other things, absence of *Lygus* damage, though these plants probably escaped *Lygus* rather than resisted its effects.

(*b*) Plants having a reasonable degree of resistance to Blackarm.

(*c*) Plants combining improved staple and improved ginning percentage, with a view to fixing the latter without receding below standard in the former.

(*d*) Plants with entire white fuzzy seed.

The first series of Serere hybrids was drastically culled in relation

to (*c*). U.4, S.G.29 and S.G.23/8 appeared to be the best elements used in this series. The remaining hybrids are now being tested for Blackarm and jassid.

Variety Trials.—Twenty varieties were tested at Serere. S.P.84.R. (ex U.4/4/2) was to the fore. Otherwise the season was more suited to the older bulks like Buganda Local and N17 (ex Nyasaland Upland). Information was gained about seed drawn from different localities, and about the rate of increase of the proportion of black seeds. There was some evidence that apparent progress is due to the decline of parent stocks rather than improvement in the progeny. Various methods were tried of eliminating the size of plant factor from Blackarm observations.

In the district trials it was shown that there is probably no case for re-introducing pure seed of S.G.29 to those areas where this variety is still (nominally) grown. S.P.84 did well, but not well enough to offset the possibility that its lint would not command full Uganda prices. B.P.52 did well in Busoga, except that it gave the highest figure for Blackarm (in a year when Blackarm did not reach dangerous proportions on any variety). On the whole, however, N17 bulk and the mass population N17.M.2 gave the best all round performances.

Seed Multiplication.

N17 bulk, reintroduced into Teso District, was well received by both people and ginners. S.P.84 replaced S.P.20 (both ex U.4/4/2) in Usuku county. The increase of N17.M.2 in Busoga was started with a 10-acre plot near Jinja. There was a marked decline in seed purity in most of the areas served by Serere.

Spinning Tests.

B.P.52 grown in Busoga gave a highest standard count of 91, which is an all time Uganda record. N17.M.2 grown in Teso and Bukedi was next at 74.

Entomology.

Resistance to *Lygus* attack was shown by various means to be bound up to some extent with hereditary characters. But it was also shown to be strongly connected with the general succulence of the plant, the most succulent plants suffering the severest reaction to attack. The problem cannot be stated in greater detail at present.

Other pests were not important.

Mycology.

The various aspects of the study of Blackarm enumerated last year

are still being investigated. The paragraphs on Agriculture and Breeding both contain references to this study.

Other diseases were not important.

Summary and Conclusions.

The local crop was a record one.

The effect of manuring on cotton under Serere conditions was given a good deal of study.

Greater quantities of seed were forthcoming from the selection plots and the number of varieties under test was increased. On the whole the very good season favoured the old N17 styles.

The work on *Lygus*, still in a formative phase, made some progress.

The study of Blackarm was further extended.

EXPERIMENTAL PROGRAMME FOR THE SEASON 1941-1942.

Agriculture.

Manurial Trial.—Possibly concluded.

Cotton Seed and Meal Manurial Trial.—Possibly concluded.

Cotton Seed and Ash Manurial Trial.—To continue.

Fertility Experiment.—To continue.

Interplanting Experiment.—Cotton with tepary beans instead of groundnuts.

Planting Methods Experiment.—A new experiment to compare continuous drilling with the present method of sowing in holes.

Gap-filling Experiment.—A new experiment to deal with the whole question of stand, gap-filling and plants per hole.

Genetics and Breeding.

Selection Plots.—A plot of perennials to be added to the previous programme.

Variety Trials.—Varieties under test at Serere to be increased to 84 and to include hybrids; district trials extended to 20 centres which now embrace north-west Uganda.

Seed Multiplication.

N17.M.2 to 200 acres in Busoga, and the surrounding area refreshed with the purest N17 bulk available.

Entomology.

Further study of the *Lygus* problem.

Mycology.

Further study of Blackarm, including the effect of manures.

TANGANYIKA TERRITORY.

PROGRESS REPORTS ON COTTON WORK 1940-41.

INTRODUCTORY NOTE

BY

J. E. PEAT.

The 1941 Tanganyika cotton crop was around 73,000 bales. Of this approximately 50,000 bales came from the Lake Province, 17,000 bales from the Eastern Province, 4,200 bales from the Northern Province, and 2,000 bales from the Southern Province. The 1940 crop was 63,000 bales, of which 40,000 bales came from the Lake Province. With the exception of Shinyanga, all this was "Local" type cotton. The Shinyanga crop is of U.4 origin; it amounted this year to 9,100 bales, a big increase from the highest previous crop, 5,940 bales in 1936.

The experimental work for the Lake Province is centred at Ukiriguru, with the exception of that for the Shinyanga district which is carried out at the Lubaga Station. It seems probable that all the Lake Province work will be concentrated ultimately at Ukiriguru, with a sub-station at Lubaga and assisted by district plots throughout the Province. Kingolwira has been the centre for the remainder of the Territory, other than the Lake Province, but this has not proved suitable. Until a suitable site for a Station can be chosen, work in the Eastern Province is to be attempted in a chain of district plots.

An important cotton survey has been in progress in the Eastern Province. Already it has clarified considerably the position there. When it is extended to the Northern and Southern Provinces, much more will be known about the possibilities of the crop in those parts.

In the Lake Province much of the cotton is grown on granite soils, which in the older, more densely populated areas are in poor heart. In some newer areas, the soil is for the present still in good fertility, and is capable of producing good yields. Towards the South of the Province a greater proportion of the cotton is grown on heavier soil types, naturally more fertile, but more sensitive to seasonal influences, excessive rain and drought.

In the Eastern Province the main production comes from rich loam soils with good moisture conditions. These areas, though capable of expansion, are limited in extent. The Kingolwira type of country—considerable in area, but very sparsely populated—does not feature largely in production. The soils are on the whole shallower, much

poorer, and with moisture conditions generally less favourable than in the areas from which at present the bulk of the production comes.

In the Lake Province, where there is a pressure of population on the land, and some maldistribution, the industry of the people is on a high plane ; but by no means can it be said that their agriculture is on the same high level. There is a considerable measure of ill-rewarded effort. In the Eastern Province, neither the industry of the people nor the level of agriculture in the cotton-growing districts could be described as being on a high plane. Subsistence is easy. Lack of population, and in some instances maldistribution of population, are important factors here limiting expansion of cotton-growing.

Taking the cotton-growing areas of the Territory as a whole, cotton tends to be something outside the ordinary agriculture. It is a cash crop, the cultivation of which has been stimulated by propaganda, and is grown mainly apart from the food crops. Rotation is little practised (more so in Mwanza), and very little indeed is done towards maintaining or improving the fertility of the soil. Manuring also is little practised, and then very imperfectly—and in many districts not for lack of cattle. Worn-out land reverts to some sort of temporary fallow, the extent depending on the land available, and the pressure of population.

Throughout the cotton-growing areas of the Territory as a whole the natives require considerable guidance in their agriculture, and especially is this true of a fairly new cash crop such as cotton. But that guidance must be based on a measure of survey and exact information. That such improvement in native agriculture is possible, though very difficult of attainment, is shown by several examples in Africa, where because of influences inducing an extreme pressure of population on the land, a system of agriculture of a high standard has been evolved, and has become the custom. The agriculture of the island of Ukara, in Lake Victoria, adjacent to Ukerewe, is a case in point. Unfortunately, with the removal, or partial removal, of the influences inducing the extreme pressure of population, that high standard of agriculture tends to decline.

Native agriculture is the life of the Lake Province, and in the biggest portion, despite the low mean yields obtained, cotton is the centre of the cash crop economy. This will become increasingly true if higher yields can be obtained. The mean Lake Province yield per acre (estimated) for the last twelve years is somewhere around 240 lb. seed cotton per acre : the 1941 figure was about 300 lb. per acre, while the 1937 figure was as low as 176 lb. per acre. Rice, and to a lesser extent groundnuts, are the other cash crops in the cotton districts, but both are liable to partial failure in a year of unsuitable rains. Cattle are

important, especially in the centre and to the South of the Province. Cotton is of great importance to the economy of the Province, but, with such low mean yields, that economy must always be somewhat precarious, especially in any period of low prices. This past season the amount paid out to the growers for cotton was £278,987, for rice £47.350, for groundnuts £26.600, and for gum £5,087. The previous season the figures were, cotton £186,771, rice £46,993, groundnuts £27,942, and gum £4,397.

In the Eastern Province cotton is not at present relatively so important to the life of the Province as it is in the Lake Province. Along the central railway line there are the big sisal estates with their demand for labour and provisioning. It is, however, of considerable importance in most of the outlying districts, and may become more so in the future.

Year by year much is taken out of the Lake Province, but very little is returned to the soil, much of which has been reduced to a low order of fertility. Leaving aside reference in such a note as this to soil erosion—the first essential, keeping the soil where it is, and preserving what fertility there is—the crying need is to get something put back in the lighter soil areas by means of manuring, green manure crops, cover and resting crops. Work on this must be one of the most important duties of a station working for the Province, affecting as it does food crops even more than the cotton crop. The heavier soil types have a bigger reserve of fertility, but under some conditions cotton-growing on them is more complicated and more difficult.

Some measure of the improvements to be effected by rotation is also highly important.

In general, problems of fertility do not occupy the same position of prominence in the main cotton-growing areas of the Eastern Province. The main areas are naturally rich, but even there, when continuously cropped to cotton, resting crops would appear desirable, particularly in the case of alienated land and in over-populated native areas. The main Kingolwira type of soil is very different : it requires comparatively high farming.

Throughout the cotton-growing areas of the Territory considerable guidance is needed in improved cultural practices, particularly time-of-planting and spacing. An assessment of the optimum time of planting would be of value, not so much in the North of the Lake Province, where early planting is now general, but possibly in the South of the Province, and elsewhere, where time of planting has to be studied in relation not only to soils and rainfall, but also to insect attack. Spacing is of great importance : by optimum spacing, considerable

increases in yield should be possible, especially on the lighter lands. In all this, as in the fertility work, survey and exact information is required.

The quality of the Eastern Province cotton, over and above the finer grading, is higher than for the greater part of the Lake Province, although the seed is of the same general origin. The soil and soil moisture position of the main areas are considerably better. There are possible doubts about much of the Lake Province cotton remaining attractive to an increasingly critical Indian market. This concerns not only a new strain such as Mz.561, but also the present " Local " cotton in the lighter soil areas and in the areas away from the immediate Lake shore. It is not enough to say " Grow a longer-stapled cotton " when large areas are either at or approaching the soil poverty line.

In the Lake Province it would seem to be very desirable to have a measure of jassid resistance. And possibly, if only as an insurance, this is true of the Eastern Province also. The breeding policy is guided therefore by the desirability of this measure of jassid resistance, plus the attempt to get sufficient fineness and length of lint, to ensure that the cotton is attractive to the Indian as well as other markets—possibly a combination not easy of attainment. There are the further necessities of yield, and hardiness—especially important for much of the Lake Province with erratic rainfall, and much poor soil. In the Eastern Province, where the conditions on the whole are kindlier, the problem of quality should be simpler. The ideal, though probably not practicable, would be one seed stock for the whole Territory, for the sake of simplicity ; the essential requirements are the same, and the fewer the strains grown commercially, the simpler the organisation and the marketing.

Stainers are the most important pest, but apart from a strict enforcement of close seasons, ordinary sanitation around seed centres, and a discouragement of cotton-growing in areas very bad for stainer host plants (*e.g.* S.W. Shinyanga and Singida), probably little can be done about them at present. A strict close season seems to be sufficient to restrict pink bollworm.

In the Lake Province, 1941 was a cotton season above average, especially so in Shinyanga. In the main cotton areas in the Eastern Province, despite short and irregular rains, cotton yields were better than usual and heavy crops of clean seed-cotton were grown. In contrast, the drier poorer areas produced very meagre crops. Kingolwira, an example of a dry poorer area, had a total of approximately 11 inches for the period March–June, the cotton being planted during March.

The Ukiriguru Station yields were heavy; the various factors influencing these are set out in the Ukiriguru report.

The Lubaga Station yields are not very satisfactory against the background of the district returns. The main cause is the comparative shallowness of much of the Lubaga soil—an especially serious factor in a season of badly distributed rains. This, and its patchiness, limits the usefulness of Lubaga as a main Station for cotton work.

The Kingolwira Station report makes melancholy reading, considered in relation to the good returns obtained in the main producing areas in the Eastern Province. Kingolwira would seem non-representative, and for a variety of reasons unsuited to the work envisaged for the Eastern parts of the Territory so far surveyed.

UKIRIGURU EXPERIMENT STATION AND FARM, AND MWABAGOLE RICE STATION.

PROGRESS REPORT FOR THE SEASON 1940-41.

BY

J. E. PEAT.

Introduction.

At Ukiriguru it has been a season highly successful for cotton, but, because of the dry December, January and February, much less so for the other cash crops, rice and groundnuts, and less so for the grain crops. Once again the value of cotton to the area is shown, and its high potential value when native yields can be increased. By contrast, cotton yields in the area around were, on the whole, moderate to very poor. The Ukiriguru cotton yields were determined by a number of factors: the depth of the hill soil; early planting; manuring; close spacing; and comparative freedom from jassid attack. As shown by the experimental results and observations, each was a factor contributing to the final yield. These results, supported by the results from instructors' District Plots, would seem to point the way to increased native production. There is no panacea, but a building-up of better yields should be possible by attention to a number of details: the planting of cotton, where at all possible, on soil with sufficient depth; early planting; on the poorer soils, manuring the cotton crop; close

spacing; and the growing of a jassid-resistant cotton. Without this last there is the risk in any year of heavy loss, even with attention to the other factors; this would almost certainly lead to discouragement, and reduce the value of a push for manuring, and early planting. It is important moreover that cotton should be considered in rotation with the grain crops, and not as something apart from the natives' ordinary agriculture.

Meteorology.

The rainfall for the growing season, November 1st to June 30th, was 25·73 inches. Cotton was easily and well established around mid-November, but the dry December, January and February made the happy establishment of other crops more difficult. The total for these three months was $7\frac{1}{2}$ inches. These were on the whole, hot, brazen, difficult months. The cotton, as will be mentioned again, was badly stunted by aphis attack, which did not clear up until good rains at the beginning of March. The rains from then until the end of the growing season could be described as good.

Agriculture.

At Ukiriguru the very good cotton yields were in contrast to the more moderate or even poor yields of the other crops grown. Sorghums suffered somewhat from the droughting in January and February. They recovered to give fairly good yields. Millet yields were only moderate. Groundnut yields, on "itogoro," the shallow seepage area soil, were poor, and the nuts of poor quality. At Mwabagole Rice Station only about two-thirds of the acreage could be planted. The better paddy yields, partly irrigated by pumping, at around $1\frac{1}{4}$–$1\frac{3}{4}$ tons per acre were considerably below those of last season. But the yield of the later-planted rain-grown rice was much poorer.

The cotton yields were very good. Excluding one area in its first year, the run of seed-cotton yields was 1,300–1,500 lb. and more per acre. Lower yields, in bulks with light seeding, were due to poorer stands. Several small bulk plots yielded over 2,000 lb. seed-cotton per acre. All the experimental and bulk cotton was planted on the hill on comparatively deep sandy soil. All, except for manurial and fertility trials, was manured at 5 tons per acre. Much of the land, including that on which were the two strain and the two spacing trials, was only in its second season since it was in native cultivation. Some of it had unavoidably been roughly treated in levelling, with the consequent destruction of structure, and bringing up of subsoil. This almost certainly increased the severity of the aphis attack. This rough treatment in levelling is unavoidable in breaking in for station

work land previously under native cultivation; the land is on a fair slope and ridged. Fortunately this rather coarse sandy soil soon forgives.

In contrast, a well-tended school block of Mz.561, following manured maize, on "itogoro," yielded around 800 lb. seed-cotton per acre. A general survey made by the pupils of the Instructor Training Centre showed, for the immediate neighbourhood of Ukiriguru, a mean yield per acre of about 280 lb. clean seed-cotton per acre for 328 growers. The mean for 26 growers in the gunguli adjoining on the hill, much of which is now added to Ukiriguru, was somewhere around 210 lb. clean seed-cotton per acre. There would appear to be reasonable room for improvement!

Cotton, Time-of-Planting.—No cotton time-of-planting trials were laid down, but in a time-of-planting observation block, cotton planted in late December and early January, yielded around 300 lb. seed-cotton per acre less than cotton planted before early December. The aphis attack may have had some effect on these yields.

Throughout the area, Instructors' District Plots were planted about the third week in November. The satisfactory yields obtained from most of them under ordinary soil conditions, compared with the run of cotton yields, must be attributed partly to this early planting.

At Ukiriguru, and for most of the area, allowing, in sorghum districts, for the planting of the grain, as early planting as the season allows would seem to be an important factor towards better yields.

Cotton Spacing.

COTTON SPACING TRIALS.

Mz.561. *Spacing on 5′ ridges.*	*Mean yield of seed-cotton in lb. per acre.*
3 Rows per ridge × 18″ × 2 Plants per hill	1,780
2 Rows per ridge × 18″ × 2 Plants per hill	1,692
2 Rows per ridge × 9″ × 2 Plants per hill	1,675
3 Rows per ridge × 9″ × 2 Plants per hill	1,618
2 Rows per ridge × 24″ × 1 Plant per hill	1,460

Difference required for Significance (P = ·05) = 134 lb. per acre.

U.4 Mixture. *Spacing on 5′ ridges.*	*Mean yield of seed-cotton in lb. per acre.*
3 Rows per ridge × 18″ × 2 Plants per hill	1,347
2 Rows per ridge × 18″ × 2 Plants per hill	1,314
3 Rows per ridge × 9″ × 2 Plants per hill	1,227
2 Rows per ridge × 9″ × 2 Plants per hill	1,218
2 Rows per ridge × 24″ × 1 Plant per hill	1,029

Difference required for Significance (P = ·05) ·145 lb. per acre.

With the good growth and crop, only the wider spacing—which, with an excellent stand, was not a wide spacing compared with native

crops—shows a drop in yield. With poorer grown native crops considerable loss of crop must be caused by much too wide spacing and bad final stands. The stands in the above trials were excellent. The U.4 mixture, as will be mentioned later, was grown because of its high jassid resistance. It did not grow out well, and even in its final growth was somewhat stunted. It did not cover the ground.

The value of close spacing is also shown in the yields from the District Plots. These were in the main on quite ordinary land for each area, and all unmanured. Yields from the plots in the poorer and drier areas, back from the Lake Shore, at very close spacing—around 24″×18″—are on the whole as good as, and even better than, the plot yields on Ukerewe Island where very wide spacing is practised—only one row to a five-foot ridge. Under not dissimilar favourable Lake Shore conditions the Uzinza plot, twice as closely spaced as the Ukerewe Island plots, yielded about 60% more seed-cotton per acre—around 1,300 lb. per acre contrasted with 800 lb. per acre.

Fertility—Manuring and Resting Crops.

Manurial Trial—Cotton; Mz.561.

Treatment.	*Mean yield of seed-cotton in lb. per acre.*
Farmyard manure—5 tons per acre...	1,124
Pen-trampled wastes—5 tons per acre	1,091
Stalks—3 tons per acre, plus farmyard manure—2 tons per acre	1,026
Compost—5 tons per acre	980
Stalks—5 tons per acre	819
Control	819

Difference required for Significance (P=·05)=126 lb. per acre.

Half the trial was under cotton, half under millet, for the purpose of testing second year effects this coming season. The cotton plots enclosed by millet suffered more heavily from aphis than the bulk cotton. It is highly likely therefore that the cotton yields are on a lower plane than they would have been had they not been so enclosed. From observation, and from other yields, it is likely that the increased yield resulting from manuring is greater than shown in this trial. The other half of the trial, millet, because of grain smut and bird damage, does not give fully significant results. The use of millet stalks without the addition of manure gave no first year increase in yield. It would seem better to use these stalks for bedding or compost making. It would also seem from the millet yield results, that on these sandy soils finely broken down compost is not so good as something "longer," for example, the pen-trampled wastes from which compost is made.

A few natives around Ukiriguru, who manured small bulks of U.4

strains and Mz.561, got satisfactory yields (considering in some instances the stands), and much better yields than their neighbours.

Manurial and Cotton Rotation Trial, 1941.—Second Year Effects.

Treatment in 1939–40 *Season.*	*Mean yield. lb. per acre.*	
	Millet stalks plus heads.	*Millet grain.*
Compost—5 tons per acre to cotton	4,368	892
Farmyard manure—5 tons per acre to cotton	4,557	853
Control—cotton	4,368	853
Kraal manure—5 tons per acre to cotton	4,620	827
Farmyard manure—5 tons per acre to millet	3,780	827
Kraal manure—5 tons per acre to millet	3,633	709
Compost—5 tons per acre to millet	3,297	682
Control—millet	2,877	551
Difference required for Significance (P=·05) = ...	700 lb. per acre	177 lb. per acre

Owing to a labeling error only four out of the six replications are available for grain yield comparisons. This increases the error figure required for significance. Yields for the total crop, stalks plus heads, are also given, for the full number of replications. There is a possible second-year increase, millet following millet, following a 1939 application of manure. But there is a marked increase, both total crop and grain, resulting from the rotation millet following cotton compared with millet following millet. The increased vigour of the rotated plots could be observed comparatively early in the season. The 1939–40 cotton crop in this trial was not very well grown. More striking results would be expected following this season's better grown cotton crop.

A 25% increase was obtained in observation blocks in the mbuga, sorghum following cotton, as compared with sorghum following sorghum.

On the light soils it is doubtful if there is much second-year effect following a manurial dressing. As noted in other countries, however, there would appear to be an appreciable increase in the grain crop following cotton in the rotation (and millet is not a sensitive responder). Cotton responds well to manuring on these light soils. A case might be made for applying the manure to the cotton crop, increasing its yield and growth, and following it with the grain crop in order to reap what remains of the second-year manurial benefit plus the cotton rotational benefit following a better grown cotton crop. Only the fear of possible jassid damage and the discouragement this would have on the manuring of cotton would prevent this being suggested. The growing of a fairly jassid-resistant cotton would remove this fear. At all events it is important that, on the suitable soils, cotton should be grown in rotation with the grain crops, and not as something apart from the natives' ordinary agriculture. If properly used it has, as a deep-rooted crop,

a part to play in that agriculture, apart from its being the most important cash crop for the Province.

Last season and this, millet crops were interplanted, after the first cleaning, with various legumes, for use as green manures, the most important being a *Crotalaria* and a *Tephrosia*, used for this purpose in the island of Ukara. Growth of these inter-planted crops this season was poorish, and the results following the digging-in of last season's interplanted green manure crops are unimportant. Nor is it expected that the results following the digging-in of this year's crops will give worthwhile results. These legumes may have a place as direct green manures, in the drier, less favourable regions, but should not be interplanted in millet. The *Tephrosia* might be especially valuable, being apparently deep rooted, continuing to grow right through the dry season where a crop such as sunn-hemp has shrivelled and died. While these interplanted green manure crops would not seem to be practicable at Ukiriguru, or for the drier areas South, they may well have much value, as at Ukara, under kindlier conditions nearer the Lake Shore. This will have to be tested.

Again, this season blocks of elephant grass and pigeon pea were easily established and have grown well. Possible complications to be watched are the breeding up of stalk borer on elephant grass, and American bollworm on pigeon pea. The first resting crop blocks, after having been down for two years, are being broken up for this coming season. They will provide experience in the ways of handling such crops.

Miscellaneous.—An " mbuga " observation plot was seeded with *Striga helmonthica*. There was heavy *Striga* infestation, but it does not appear to have done much damage, probably because of the dry January–February. The sorghum plot yields, manured and unmanured, and the millet plot yield (unaffected by *Striga*) were similar—around 1,200 lb. per acre.

Sorghum yields were fairly good. Some quick-growing dwarf sorghums from Swaziland stood up well to the drought, better than the local sorghums. While possibly of little value in ordinary production, these may have a famine value. A long-headed Indian millet showed well. It is early maturing, but not a good keeper. There is a keen demand for it from the Indian community for food, but no native demand for seed. Maize promised well but was affected by the drought. Stover yields are good, but grain yields only fair. A considerable acreage was under groundnuts. Both the yields and the quality of the nuts were poor.

The seed farm side of Ukiriguru and the other activities of the farm are being maintained.

It was not a favourable year for the rice work. Only about two-thirds of the Mwabagole Rice Station could be planted, even using pumping. The yields on the partly irrigated lands were fair, though considerably below those of last season. The yield of the later planted non-irrigated rice was poor. Afaa and Maji Maji were bulked for seed distribution. There is a strong demand for all the seed that is available. Small bulks of Afaa from the Coast were grown, and selections in them were made for bolder grain.

Some 400 acres of hill land have been added to Ukiriguru on payment of compensation to the native occupiers. This is being levelled and prepared for Station work. There is now a sufficiency of light land for cotton and fertility (resting crop) work, but the unevenness and irregularities will affect experimental work at least for a couple of seasons. In the new area there is room for future development; housing, buildings, roads, and tree blocks.

Cotton Breeding.

Cotton Strain Trials.

Strain.	*Mean yield of seed-cotton in lb. per acre.*	*Mean yield of lint in lb. per acre.*
"Local"	1,604	516
Mz.457	1,589	520
Mz.561/2	1,558	502
Mz.561	1,512	485
U.4 Mixture	1,332	500

Difference required for Significance (P = ·05) = 112 lb. seed-cotton per acre.

Strain.	*Mean yield of seed-cotton in lb. per acre.*	*Mean yield of lint in lb. per acre.*
"Local"	1,501	483
Mz.457	1,468	480
Mz.561/6	1,428	428
Mz.561	1,403	450
7L6 (ex U.4)	1,269	454

Difference required for Significance (P = ·05) = 125 lb. seed-cotton per acre.

These yields are very good, the yields of "Local" most surprisingly so. They demonstrate what "Local" can do, closely spaced, when conditions allow it to grow out, and when jassid is unimportant. The results are far from what was expected. The crop was badly hit by aphis: as a result it was stunted in its early growth and it shed most of its young buds and flowers. The main crop consequently had to be made and ripened between late March and the end of June (the plants had shed almost all buds until early March and picking was completed

by the end of June). The U.4 mixture was a mixture of several highly jassid-resistant Gatooma U.4 strains, included in the trial because of the high degree of jassid resistance—a mixture was unfortunately necessary because of serious seed shortage. Both this U.4 mixture, and 7L6, a highly jassid-resistant Gatooma U.4 strain, presented, even at the end of the season, a somewhat stunted appearance. They did not grow out properly and fill the ground contrasted with the Lake types. This lack of vigour under these conditions is characteristic of much of the U.4 material grown this past season, whether derived from Barberton or Gatooma. It will be noted that in both trials the U.4s yielded significantly less seed-cotton, but owing to their higher ginning percentages, there was little difference in lint yields.

Though " Local " and Mz.561 yielded much the same at Ukiriguru with a highly productive crop, the mean of eight District Plots shows Mz.561 yielding about 25% higher than " Local," and Mz.457 better than half-way between them (Mz.561 around 1,030 lb. per acre to " Local," around 810 lb. per acre). Incidentally these District Plot mean yields are very satisfactory, considering the run of native crops and the fact that most of the plots were on quite ordinary soil and all were unmanured. They point the way to better native yields. There seems good reason for believing that, under poorer native conditions and with a measure of jassid attack, Mz.561 would be substantially a better yielder than " Local." Both Mz561 and Mz.457 cropped well in multiplication at Uzinza, though in some areas Mz.457 suffered from jassid attack. In the District Plots the U.4 mixture, included for high jassid resistance, did best on the Lake Shore and poorest in the hinterland plots where it was too small and stunted in growth. This coming season Mz.457 will be in general cultivation in Ukerewe Island and Mainland, and Mz.561 in Uzinza.

Lint samples from the Ukiriguru trials and some other lots and some from the District Plots have been sent to Manchester and India for reports and spinning tests. The quality of the Ukiriguru crop, with the high yields obtained, is good, and seems comparable with that of the Lake Shore cotton grown under more favourable soil and rainfall conditions. In the same way the cotton from the better District Plots seems of better quality than most of the native cotton around. Factors which make for heavy yielding, unless the crop is forced by much too close spacing, should make for lint quality. The quality of the general run of cotton is pulled down by immature cotton from jassid-struck crops and crops grown on impoverished or unsuitable soils.

From comparable samples Mz.561 lint would appear to be similar in quality to " Local," possibly even very slightly better, with Mz.457

lint probably better still. But in commercial cultivation the slight jassid resistance of Mz.561 may result, commercially, in a somewhat better general grade of lint.

As has been mentioned, most of the U.4 strains, even under the Ukiriguru conditions of the season, seemed to lack vigour, and did not cover the ground. This season this may have been influenced by the effects of aphis attack on hairy plants. The yields, however, in spite of the plant size, were excellent, a number of plots yielding over 2,000 lb., and much yielding around 1,500 lb. seed-cotton per acre. Added to this, the ginning percentages were distinctly higher than for the Lake-type strains. The Barberton strain 6250, though small growing and somewhat lacking in good jassid resistance, yielded well. 9L18, a Gatooma selection from 7L5, and other selections from this strain and from 7L5 itself, were vigorous and did well. They combined good cropping, fairly good jassid resistance, and better quality lint.

There are highly jassid-resistant selections within the Lake-type material, though generally speaking the hairiest selections have unfortunately short and coarse lint, and the finest silky lint comes from comparatively glabrous plants. It should be possible, however, to achieve a compromise, a fair degree of jassid resistance allied to reasonably fine lint. This is the present aim. Among the Lake-type material there would appear to be promise of getting this in the selections grown this past season. In the U.4 material some of the selections from 9L18, and the parent 7L5, seem to show this. Some of the strains from the Gatooma U.4×Cambodia backcrosses are also still worth carrying on. A fairly jassid-resistant selection, made at Gatooma from Uganda B.P.50, with long fine lint, might be important.

A large number of new selections were made within the Lake-type material and from the U.4 strains.

There is a big range of possible material ; more than can be handled at all adequately under present conditions.

Entomology.

Jassid.—Jassid was of minor importance on Ukiriguru, but it was a serious factor in reducing cotton yields in the area immediately around. Possibly the severe aphis attack at Ukiriguru prevented early breeding-up there. Thus, on the Station resistance to jassid did not come into play as a factor influencing yield. Throughout the Province jassid was in some areas serious, in others unimportant. It caused loss this season in areas where last season it was unimportant, and *vice versa*. It is essential, to be safe, to get as high a measure of jassid resistance as is compatible with lint quality and yield.

Aphis.—As has been mentioned, the Ukiriguru cotton crop was heavily attacked by aphis in the latter part of January and in February. Severe stunting of the plants was caused. The dry, brazen, weather conditions of January–February were conducive to aphis attack, but undoubtedly conditions were considerably aggravated by the rough treatment which much of the new land received in levelling. Aphis was serious in many areas throughout the Province, but disappeared with the beginning of the March rains.

Lygus.—No *Lygus* damage was seen. Cotton observation plots planted in the "mbuga," in contrast to the failures of last season, produced good yields.

Cotton Stainers.—Though at Ukiriguru cotton stainers were present from April onwards, the loss caused was small. Some loss was caused in later supplied, somewhat lank, bulks of Mz.561 substrains. At the Station and in the districts *D. superstitiosus* and *D. nigrofasciatus* were the most prevalent species. *Callidea* was also present. Cotton staining was more serious early in the season in the hinterland than on the Lake Shore. *D. fasciatus* was only seen in quantities where it had been allowed to breed up at ginneries or at seed-issuing centres. This could readily be prevented. Only occasional *D. cardinalis* were seen.

American Bollworms.—Quite serious American bollworm loss was caused in areas throughout the Province : there was, however, no such loss at Ukiriguru. It would appear that the loss is partially linked with the planting of very early maize. A survey might show if this were so, and how by slightly altering planting customs loss might be reduced, if not prevented.

Mole Crickets.—Trouble was caused at Ukiriguru by these pests and cotton stands elsewhere in the Province were much reduced by them. Natives in the Ukiriguru area suffered serious reduction in stand.

Summary and Conclusions.

1. The seed farm and general activities were maintained. The rainfall in December, January and February was poor. Grain yields were moderate. Groundnut yields were poor.

2. Rice yields at Mwabagole Rice Station were lower than last season. The yield from unirrigated rice was low. There is a strong demand for what seed of the varieties Afaa and Maji Maji is available. Selections were made for a bolder grain in Afaa strains from the Coast.

3. Contrasted with the poor to moderate groundnut, rice, and grain yields, cotton yields on Ukiriguru were excellent, and this despite severe early aphis attack. These yields are in marked contrast to the very poor yields obtained by the natives immediately around the

Station. No one factor was responsible for the Ukiriguru yields, but results show how they have been built up in a number of ways. They point the way to considerably higher native yields, and consequent increased production.

4. Cotton on the deep hill soil grew out and yielded much better than cotton on the shallow lower lands. The value of early planting was again shown, and the high importance of close spacing and good stands. These results are supported by the results from District Plots. Cotton responded well to manuring. The rotation and second-year manurial results suggest that it might pay to manure cotton and follow that with the grain crop. At all events the value is shown of working cotton in as part of the general rotation.

5. Fear of jassid damage might discourage the use of the manure on the cotton crop. Jassid, though unimportant on Ukiriguru, was severe immediately around and caused loss in areas throughout the Province—in some crops serious, in others minor, and in others moderate, damage. Aphis was very severe, but the cotton crop recovered to make a heavy crop.

6. At Ukiriguru, strain trial yields were high, but no significant yield differences showed between "Local," Mz.561, and Mz.457. In the District Plots, however, Mz.561 showed up as appreciably better than "Local," with Mz.457 somewhere intermediate.

7. There is difficulty in getting fine silky lint allied to a high standard of jassid resistance. But within both the Lake type and the U.4 selections there is hope of a compromise—a moderately hairy plant with fairly fine lint. Some of the most promising U.4 lots are from a Gatooma U.4 strain 7L5. A large number of new selections have been made. The Ukiriguru lint for the season is of high quality, and more comparable with the better Lake Shore areas.

8. Stainer loss was on a low level. In districts, American bollworm caused considerable loss. Around Ukiriguru and elsewhere mole crickets caused serious reduction in stand.

PROGRAMME OF WORK FOR SEASON 1941-42.

The experimental work on the necessarily limited scale that can at present be attempted is designed to test out practical methods of restoring and maintaining fertility in the lighter soil types; to test the value of, and increases to be effected by, manuring and rotation; to show how cotton yields may be improved. In the cotton-breeding work the

aim is to combine with the other necessary agricultural qualities as high a degree of jassid resistance as is compatible with a fair measure of lint fineness : this latter must be determined by the market.

1. The seed farm and general activities, and the Mwabagole rice work, will be continued as well as is at present possible.

2. The development of the new area will continue ; levelling, and preparing it for Station work.

3. Further manurial trials will be laid down, and second year and rotational effects followed up. The first blocks of resting crops will be planted to cotton and millet, manured and unmanured. If possible, two fairly large-scale resting crop trials will be started in the new area. Blocks of land in this area will be put down to elephant grass, others to green manure.

4. Cotton spacing trials will be continued. Strain trials will be continued. Strain trials will include some of the newer " possible " U.4 strains. One trial will be on " mbuga."

5. The most promising of the selected material, Lake type and U.4, will be multiplied. There is a large number of new selections. New material from Barberton will be grown, some as a basis for selection.

6. A start will be made, for the first season somewhat tentatively, with trial District Plots, investigating extensions of Ukiriguru guided by Ukiriguru instructors. Cotton strain and spacing trials will be attempted, and as with the instructors' observation plots, the lint will provide material for quality comparisons for the different areas. A start will be made to obtain some estimate of the response to manuring in the various districts ; how resting crops and, in the better areas, how inter-planted green manure crops, respond, and later what effect they have

LUBAGA EXPERIMENT STATION, SHINYANGA. PROGRESS REPORT 1940-41.

BY

A. N. PRENTICE.

Weather.

The growing season was a difficult one for crops. Rainfall on Lubaga from November 1st to May 31st was 25·43 inches, a total well below normal, but quite adequate for crops had the distribution been fair ; but of the total, two storms of 3 inches and 4 inches at the start of the season did more harm than good, and the distribution of the remainder was erratic. The combined fall, mostly in the form of

ineffective showers, was barely 5 inches for the two critical months of February and March, and all crops felt the strain. April–May rains were satisfactory. Rainfall distribution in the district as a whole was better than at Lubaga.

AGRICULTURE.

About 40 acres were planted under cotton in three main spells, as opportunity offered. The first planting, at the beginning of December, was got in under good conditions, but the others, at roughly three-week intervals, had to take their chance. Growth and yield followed the planting date fairly closely; the earlier plantings gave satisfactory yields, the later plantings poor yields.

The rotation crops all gave poor yields. This was due to poor rainfall, as pests and diseases were not serious, and indeed the witch weed (*Striga hermonthica*) infestation on the grain crops was the lightest in the memory of the native farm overseers.

The soil of Lubaga is a blackish, friable loam, an excellent farming soil as far as it goes, but its shallowness—the limestone subsoil, often little decomposed, is struck sharply at an average depth of not more than two feet—seemingly masks its virtues in a dry year. Much of the district soil of this type is probably similarly shallow. On Lubaga this season even tie-ridging and manuring could only partially offset the effect of the semi-drought on such soil. Manuring at 5 tons per acre certainly showed benefit to both cotton and grain crops, but patches of deep (unmanured) soil showed at least an equal order of benefit. In future, by using very large ridges, it may be possible to mitigate this lack of depth in the soil.

Cotton was relatively the most successful crop this season. Growth was medium to small, and almost complete shedding of buds and young bolls took place as the semi-drought of February–March began to tell on the plants, but by then the early-planted cotton had set, and eventually ripened, a good crop. In this early planting, all the crop was made from bolls set prior to the flowering peak in mid-March. A second flowering peak in May gave no useful crop because of heavy staining.

A simple factorial experiment with cotton on shallow black soil at Lubaga was laid out to give the crude cultural contrasts, a farmyard manure (at 6 tons per acre) *versus* no manure, close spacing ($3' \times 1'$) *versus* wide ($3' \times 2'$), and flat *versus* ridge cultivation. The main treatments showed no obvious differential response to the other treatments or combinations, and interaction significances have not been calculated. Ridge cultivation in itself rather unexpectedly depressed yield considerably; the ridges were small, and 3′ apart,

and seemingly these small ridges dried out the soil even more than flat cultivation, under the particular conditions. Close spacing in itself was about as beneficial to yield as manuring in itself. The table below gives some of the comparisons.

BLACK SOIL. PLANTED MEDIUM LATE (REPLANTED).

Treatment group.	*Yield in lb. seed-cotton per acre.*	*Least significant difference. P=·05.*	*cf. FYM-flat-close =100.*
F.Y.M. (irrespective of other treatments)	460	66	80
No F.Y.M. ,, ,, ...	383	(significant)	67
Flat ,, ,, ...	467	54	81
Ridged ,, ,, ...	377	(significant)	66
Close spaced ,, ,, ...	482	65	84
Wide spaced ,, ,, ...	361	(significant)	63
F.Y.M., flat, close spaced	574	Not tested, obviously significant	100
No F.Y.M., ridged, wide spaced	324		56

Shinyanga district cotton is on the whole well tended, the fields being very free of weeds towards the end of the season, but weeding is sometimes left until well on in the life of the crop. A Lubaga experiment on cotton gave yields of a low order, but showed that complete lack of weeding suppressed the yield to levels far below that of a weeded crop, and that weeding under wet soil conditions (a practice not unknown in the district) gave poorer yields than weeding under orthodox good farming conditions, though the difference in this case was not significant.

WEEDING EXPERIMENT. MEDIUM-LATE PLANTED. BLACK SOIL. NOT MANURED.

Treatment.	*Yield per acre, lb. seed-cotton.*	*cf. dry weeding =100.*
Orthodox (dry) weeding	436	100
Wet weeding	380	87
No weeding	186	43

Difference required for significance (P=·05)=78·5 lb. seed-cotton, or 18 in last column.

The cotton time-of-planting trial was on a randomized plot layout, with the plots separated from one another by being scattered through a field of sunnhemp. The object of this isolation of the plots was to circumvent " unfair " insect attack ; and in this, so far as could be told from observation, it succeeded. The late-planted plots bred up their own jassid without being unnaturally bombarded from the early plots, and stainers did not congregate in the earlier plots with more growth to the favour of the small, late plots (last year, with the ordinary randomized block layout there was a suspicion of this) but seemed to take the plots as they found them. No counts were made to confirm these rather sweeping statements, but the lack of jassid bombardment

at any rate was fairly obvious. The late-planted plots definitely suffered more from jassid, and this was fairly clearly a function of their own lateness. It could be argued that since much of the district cotton is planted in large communal fields, often with a range of planting dates within the one field, then the solid randomized block layout more truly reflects district conditions. But district habits can be made to conform to better practices, if these practices can be confidently defined.

The effect of time of planting on staining is brought out in the table below. The early December planting, which would almost certainly have out-yielded all others, was unfortunately missed altogether. The mid-December planting struck very hard weather conditions, and the stand was about 20% poorer than that of the other treatments; but any adjustment for stand was considered unfair under the terms of the experiment.

TIME-OF-PLANTING EXPERIMENT. BLACK SOIL. NOT MANURED.

Date of Planting.	*Yield per acre, lb. seed-cotton.*	*cf. Mid-December =100.*
Mid-December	448 (of which 21% stained but saleable)	100
End-December	505 ,, 20% ,, ,,	113
Mid-January	287 ,, 31% ,, ,,	64
End-January	288 ,, 61% ,, ,,	64

Difference required for significance (P = ·05) = 97 lb. seed-cotton, or 22 in last column.

A fairly elaborate district trial, with blocks or plots scattered so as to include flat, ill-drained " mbuga " land, and ordinary well-drained land, will be attempted next season. Some of the native growers are suspicious of early planting on these " mbugas " and there may be something in their contention that late planting is the better in such places. Observation on the point gives contradictory evidence.

BREEDING WORK.

Selection and testing were continued.

Jassid attack, although not nearly so intense as last year, lasted at a fair level from January until June, and the cumulative effect could be seen on the more susceptible strains and the later planted lots. Even susceptible strains however, planted early, were not seriously affected in yield by jassid damage.

The U.4 strains brought from Gatooma two years ago cropped well for their size, but they are mostly naturally small, compact, early types, and the season kept them even smaller than usual. Typically, 7L6, an almost jassid-proof U.4, could not make up by its prolific habit and good jassid resistance what it lost in bulk of growth. The more vigorous 6C/6, a Cambodia × U.4 backcross, responded better to the conditions, and other similar crosses did well, but 9L18, a type off the

usual Gatooma U.4 run in several ways, was the most successful strain of the year. 9L18, although its jassid resistance is not first class, is a fairly vigorous plant of open framework with lint length and ginning percentage above the usual Gatooma standard, and a much bigger boll. The loc weight of 9L18, 1·05 grams, was in fact greater than that of any of the strains listed in the table below and significantly greater than that of all except Mz.561. In general the big-bolled strains, which are often the strong-growing strains, have done well this year.

BLACK SOIL, F.Y.M. AT 5 TONS PER ACRE. EARLY-PLANTED.

Strain.	*Type.*	*Yield in lb. lint per acre.*	*cf.* 998=100.
9L18 ...	U.4 (Gatooma)	281·8	113
Mz.561 ...	Uganda Upland type (Mwanza)	250·7	100
998	U.4 (Barberton) Control	250·0	100
9L14 ...	U.4 (Gatooma)	245·7	98
6250... ...	U.4 (Barberton)	241·3	97
7L6	U.4 (Gatooma)	229·5	92
7L6	U.4-derivatives of 7L6	220·8	88

Difference required for significance (P=·05)=25·1 lb. lint, or 10 in last column.

6250, which did well last season, is a small-growing type which was not favoured by the conditions. It was included in about a dozen district plots, each plot containing the same six strains, and it behaved most variably, being either among the obvious leaders of the plot, or among the poorest. In a second strain trial on Lubaga, planted three weeks later than the first, on unmanured but probably rather deeper land, 6250 found things more to its liking and yielded well above the control.

BLACK SOIL, UNMANURED. MEDIUM-EARLY-PLANTED.

Strain.	*Type.*	*Yield in lb. lint per acre.*	*cf* ·998=100.
6C/6 ...	Cambodia × U.4 backcross	228·8	128
L24	U.4 (ex Barberton 5.126?)	223·6	125
7C types ...	Cambodia × U.4 backcross	219·8	123
6250... ...	U.4 (Barberton)	215·0	120
Mz. 561 ...	Uganda Upland (Mwanza)	202·8	114
7L6 types ...	U.4 (Gatooma)	196·3	110
7L1	U.4 (Gatooma)	192·9	108
Mz. 457 ...	Uganda Upland (Mwanza)	189·2	106
998	U.4 Control	178·5	100
4/4/2 ...	U.4 Standard district cotton, now being superseded by 998.	177·0	99

Difference required for significance=23 lb. lint, or 13 in last column.

A trial at Usogore ginnery failed to pass the F. test : but for what it is worth, it showed Mz.561 at the top, with 998 and 4/4/2 at the bottom.

Lint quality tests will probably show the Uganda Upland types (Mz.457 especially, and Mz.561) to be well above the U.4s. The lint of the Gatooma U.4s is relatively short, and harsh, although 9L18 is well above the ruck. 998 is probably better than most Gatooma U.4s in quality, but 6250 has probably the best lint of the Barberton U.4s under observation.

Shinyanga is the only district in the Lake Province growing U.4 cotton. Uganda Upland (Mz. Local, now being replaced by Mz.561 and Mz.457) is grown in the rest of the Province. Until the outbreak of war, the Shinyanga ginner was compensated for the slightly lower price fetched for his lint, by the higher ginning percentage of the Shinyanga cotton, which he bought as seed-cotton at the standard Province price. Now, with a restricted market for the Shinyanga style of lint, the discount between this and the price fetched for Mwanza lint has widened, and the ginners also allege a drop in the ginning percentage of U.4/4/2. The current replacement of U.4/4/2 by 998 should raise the ginning percentage again, but Shinyanga may have to come into line with the rest of the Province and grow a comparable lint. Mz.561, unfortunately, has not been tested in the district in Shinyanga, but on its showing at Lubaga over a number of years it seems to be in the same class as the present district strains, as a yielder. It will be tested widely in the district next year.

Some new Barberton U.4s were under observation, and the more promising, notably the jassid-resistant 880, will be tested in trials next season.

The single-plant lots have much of interest this year. The best of the U.4s and the U.4×Cambodia backcrosses have excellent lint and obviously good cropping power. Lint quality still awaits expert opinion. Some of the lots out of Mz. Local, 561, and 457, have also excellent hair, fully up to that of the best U.4 lots, but their lint quality, on first inspection, seems to have dropped. However, without reaching extremes, the general level of combination of desirable qualities is very promising in a score of lots from either parent stock.

Entomology.

Insect attack was not so heavy as last year. Stainers were a serious pest from mid-season onwards, but the damage caused by jassid was not crippling, and other pests were negligible.

Jassid.—A few nymphs were seen as early as January 7th, and by the end of January counts were recording around 0·6 nymphs per leaf. Counts then showed a drop until the end of March, when a figure around 0·7 nymphs per leaf was reached, and this dropped slowly to about 0·3 in June. Thus the attack was not heavy, and its protracted nature caused only skin-deep symptoms on the early-planted cotton. Later planted cotton, on which no counts were made, obviously suffered more from jassid.

In the district, on the whole, jassid attack was light this year, many crops being "touched" but few seriously injured.

Stainer.—A first attempt was made this year to get some quantitative estimate of stainer numbers and damage, but records are not reliable. However, some generalizations can be drawn. *Dysdercus superstitiosus* was first seen on cotton in early February, and in January had been found on wild host plants of the Abutilon type. *D. fasciatus* came suddenly into the picture in the third week in February, and soon took the lead over *D. superstitiosus*. Populations at the end of February were around 1,000 adults per acre, but the *fasciatus* increase pushed numbers up to the 2,000 mark by mid-March, to around 6,000 after boll-opening started in March, and up to well over 10,000 adults per acre by the end of April. *D. fasciatus* made up at least two-thirds of the heavier populations; *superstitiosus* remained fairly steady until May, when it faded out; *cardinalis* built up gradually from an early start to a fairly high peak in May; and *nigrofasciatus* was always scarce, while *intermedius* was not seen. *Phonoctonus*-like predators were common.

The early planted cotton had set its crop before stainer could harm it unduly. Records and observation showed that there was little or no bud or boll shedding due to insects; the heavy shedding loss, which became absolute among the buds and young bolls in March, was due to the droughty conditions. This lack of young bolls may have been the cause of a temporary drop in stainer populations about the beginning of April. Late-planted cotton, and the second (May) flush of flowers on early-planted cotton, failed to produce any crop, such bolls as survived the young stage being badly stained. Medium-late planted cotton suffered from stainer in intermediate degree. Many, probably most, of the district crops, had lighter stainer attack than Lubaga, but occasionally *D. fasciatus* attack was very heavy, especially in some baobab areas, or in the vicinity of carelessly cleaned cotton stores.

Cotton seed traps, on two large patches of cotton at Lubaga, seemed promising for the first few days after they were laid down in late February; at first they were accounting for stainers in numbers of the same order as the estimated stainer populations per acre, but after a few days, the trapped numbers dropped, while the populations per acre rose steadily. There was a suspicion that laying of the traps actually helped to bring *D. fasciatus* into the cotton fields. All four species of stainer were caught on the traps, in apparently much the same proportions as their field populations.

Callidea.—*Callidea* sp. made a sudden move into the early cotton in February. It was plentiful in later-planted cotton in April. No attempt was made to apportion staining damage between *Callidea* and *Dysdercus*. Occasional district cotton fields were heavily infested.

Bollworm.—Both American (*Heliothis armigera*) and Spiny (*Earias* spp.) bollworms were noted on Lubaga, but were quite unimportant this season. In the district both types were commonly present, taking a steady but small toll; only one district crop was seen seriously affected by American bollworm.

Other Pests and Diseases.—Aphis was unimportant, both on Lubaga and in the district. *Oxycarenus* sp. appeared in numbers on open bolls, late in the season, on Lubaga. Leaf spots gave little trouble. *Rhizoctonia* or something similar was seen on some of the district cotton in February, but was not widespread.

Miscellaneous.—The " Kaya " School, the dairy herd, and the other activities were run as usual.

The district lacked an Agricultural Officer until January, but the native instructor staff, with a minimum of supervision from Lubaga, did much useful work in encouraging earlier planting and closer spacing of cotton. Enough was seen of these two measures on a commercial scale to leave little doubt about their benefit, in at least the majority of places. The trend, of course, for the past few years, has been towards earlier and closer planting. The more intensive application of the measures, with the co-operation of the Administration and the chiefs, must have been partly responsible for this season's relatively good yields per acre. A yield per acre figure is guess work in Shinyanga (because of the difficulty of getting accurate acreages; the ginnery return gives accurate total crop figures) but yield has obviously improved on last year. The season suited cotton in most parts of the district. The total crop was 9,200 bales of lint, compared with the 1936 record crop of 5,940 bales.

Summary and Conclusions.

The season was notable for a badly distributed rainfall, and on the shallow, although otherwise good, soil, of Lubaga, crops suffered accordingly. Early-planted cotton set a good crop, up to 1,200 lb. seed-cotton per acre, before flowering shut down completely as the result of hard conditions in February and March. A flush of flowers on this cotton in May, and the main flowering of the late-planted cotton, gave little or no crop because of heavy stainer, chiefly *D. fasciatus*, attack. Cotton planted midway between the extremes gave an intermediate crop. Insect attack other than stainer was not heavy.

Further trials on Lubaga, and large-scale evidence from the district, emphasize the importance of closer spacing and earlier planting to the yield of cotton under local conditions. Most of the district had a rather

better rainfall than the Lubaga area, and yields in the district were better than last year.

Selection work amongst many lots now known as good for yield and jassid resistance is being directed more to lint quality. Gatooma U.4 strains, tested for the first time in formal trials, gave very satisfactory yields ; most of them have relatively poor-quality lint, but one of the yield leaders, 9L18, seems well above Gatooma average in this respect. The high quality Uganda Upland cotton, Mz.561, which has done well on Lubaga, may have to replace the present district U.4 cotton as a first move, because of wartime marketing difficulties with U.4 lint.

Systematic observation and recording work in the district, and study of the general applicability of Station results to the range of district conditions, have been intensified.

PROGRAMME OF WORK FOR SEASON 1941-42.

Work on soil betterment will be continued. A rotation experiment is already under way, and a second, designed to give fuller information, will be started ; the range of green manure and resting crops under observation will be extended if possible by the inclusion of local wild legumes and grasses ; compost is now available, and the merits of this and other ways of putting organic matter back into the land will be compared.

Further selection work within the range of jassid-resistant cottons, now isolated will be influenced by the call for better lint. Breeding work will continue the usual sequence, and strain trials will be extended to the district, if possible.

Work on spacing, time-of-planting and other cultural problems will continue.

District records on cotton will be made as full as possible.

All station work is related to district needs. The District Agricultural Officer, Mr. Allnutt, is fully sharing the district investigation work and keeps in constant touch with the Station. An important part of next season's programme is a fairly ambitious scheme of district-wide blocks, designed to give information on strain, spacing, time-of-planting, soil type and various interactions.

KINGOLWIRA EXTENSION FARM.
PROGRESS REPORT FOR THE SEASON 1940-41.

BY

A. H. McKINSTRY.

Introduction.

On the Station, the season's rainfall was the worst on record; it fell short in total (21·62 inches), and was poor in its distribution. Furthermore, the cotton crop was severely damaged by Internal Boll Disease. These adverse factors, considerably hampered progress in the plant-breeding, and other work with cotton.

Last year, insect damage, caused more particularly by American bollworm and jassid, resulted in meagre yields; staining also, was noticeable in the small crop. Thus this is the second season in succession that difficult conditions have been experienced on the Station.

The native peasant farmers in the Settlement Area obtained very poor returns from both their food crops and their cotton cash-crop; some of them got no returns from either source.

In the main cotton-producing areas rainfall was reported to be short and irregular in its distribution at the beginning of the season, in March and April. There, however, conditions of soil, moisture, etc., are on the whole more favourable to plant development than on the Station; and the commercial crop finished well. Yields were above average and there was little staining to be seen in the mature crop.

Meteorology.

An analysis of rainfall figures shows that good rains, well distributed, fell from January 11th to 25th; the total for the month, 4·28 inches, was good. The total rainfall for February, 2·30 inches, fell over a period of three days about the middle of the month. Of the 5·39 inches total for March, 3·50 inches fell in two rain-storms during the first week, and 1·42 inches over the last three days of the month. April, usually a month of well-distributed showers was, this season, the driest April on record. Rains in the first half of May were evenly distributed. A few showers fell in June.

Agriculture.

Rainfall distribution during March and April, the main planting months, was very poor, and it was not possible to establish the main acreages of maize and cotton in proper time. The droughty conditions also affected adversely the development of the sorghum crop planted in January; yields from this crop were very poor. The main cotton

lands referred to below received a dressing of 5 tons of compost per acre.

Observation Plots.—Times-of-Planting.—This was a first attempt to try out planting cotton on January, February and early March rains. The crop is usually sown about mid-March. Plots were planted about mid-January, mid-February and early March, on a range of soils.

The yields, given in Table I, are in favour of the " earlier " plot, in both instances.

TABLE I.

YIELD IN LB. SEED-COTTON PER ACRE. SPACING 3′×3′, 2 PLANTS.

Date of Planting.	*Yield.*	*Site and remarks.*
15/1	201	Block XI ; poorer, red soil area, on wind-swept ridge
6/3	141	
19/2	401	Block II : richer, grey-black loam, near the River
5/3	182	

Plants in the plots on a greyish sandy soil in Block X were badly damaged by jassid and stainer attack.

Stainer damage occurred on the crop in all plots, but, from observation, breeding-up of these insects was on a small scale. It is not thought that this breeding-up materially increased the numbers of the pest in the main crop—if such emigrations did occur. Jassid, although present, did little damage except in the case recorded above ; there it was severe ; it was so last year also, in the same field. American bollworm damage was negligible, particularly on the January and February plantings.

As it is important that the yield potentialities of the different soil types which lie at different elevations on the farm should be fully tested, a further series of plots will be planted next season.

Past experience has indicated that the red soils on the ridges, although of greater depth, are poorer in fertility than the valley soils. The red soils form a large fraction of the area under development. Mr. G. Milne, Soil Chemist, Amani, kindly made a survey of the different soil types in June. The results of his investigations are not yet available.

Spacings, and Compost Applications.—These variables were included in two large trials ; one was planted on March 5th–6th, while the other was dry-planted on March 21st. Owing to storm damage, initial plant stands in the earlier-planted trial were poor ; rains were inadequate for refilling the seed in good time. Stands were good in the later-planted trial, but American bollworm and stainer damage destroyed the crop. The following results, all of them statistically significant, were obtained with yields of about 200–300 lb. seed-cotton per acre, on plant-hill stands of about 50%, from the trial planted March 5th–6th :—

1. An application of 5 tons per acre of mature or well-rotted compost increased yield by 37 and 66 lb. seed-cotton per acre when

compared with 5 tons per acre raw compost, and no compost treatments respectively. The difference between 5 tons raw compost and no compost is also significant.

2. Two plants spaced at 36″ in the row, the normal spacing, gave the lowest yield when compared with 2 plants at 18″, 1 at 18″, or 2 at 24″. The greatest difference, that between 2 at 18″ and 2 at 36″ amounted to 115 lb. seed-cotton per acre.

Four trials, in which two spacings (2 plants at 18″. and 2 at 36″) were combined with (*a*) applications of compost, (*b*) hoeing the land to a depth of about 4″, and (*c*) merely scuffling the surface of the soil before planting, were sown on a range of soil types in the Settlement area. These trials were for the purpose of demonstrating the benefits to be derived from certain practices of mixed-farming, which will soon have to be adopted in land-use, in the Settlement area. Unfortunately, the season was unfavourable, and three of the trials must be regarded as failures. The following conclusions may be drawn from the fourth trial :—

1. Despite the fact that the 2 plants at 18″ plots had poorer plant-hill stands than the 2 at 36″ plots, they yielded more heavily : at the rate of 87 lb. seed-cotton per acre, on a mean yield of 440 lb. seed-cotton per acre. This result is significant at $P = \cdot 05$.

2. Although there were no significant differences between the various land-treatments, yields were generally in favour of applying compost and hoeing it under rather than merely scuffling the surface soil.

The results from the above trials have particular application on Kingolwira Settlement, where efforts are being made to establish mixed-farming with cattle, in a comparatively " dry " area, in tse-tse fly country.

Yield differences of about 100 lb. seed-cotton per acre in favour of certain of the spacing treatments recorded above, represent at present prices, a gain of about 8–10 shillings (E.A.C.) to the native cultivator ; a gain which is about equivalent to the amount of the native's poll-tax. Or, alternatively, about twenty working-days, at 50 cents (E.A.C.) per day.

Cotton Breeding.

Observation plots of a range of strain types were planted on two occasions under difficult rainfall conditions ; the first about March 5th–6th, and the other about the end of the month and in early April. Single-plant selection plots and bulks were also planted on the latter occasion. Plant stands were poor in the earlier planted strain plots, and rogueing of the more interesting strains further reduced stands.

A fair crop of bolls was produced in the later planted plots ; but drought conditions and internal boll disease damage considerably interfered with the production of sound seed. In fact, after two successive difficult seasons seed stocks of some of the strains are very low.

There are no comparable yield figures for different strains, and boll, lint, and seed characters have not yet been analysed. However, the following notes are recorded for possible future reference :—

1. U.4 strains, particularly a number from Gatooma, were again outstanding for their quick cropping, and compact style of fruiting. 9L34 and 9L18, two of the better-linted strains, may in time be used in crosses with some of the selections from " Local."

2. Of the 35 selections from " Local," 35/244 and 35/553, were the most promising, and of these 35/553 and its selections are preferred ; they are, however, still a mixed bag, and therefore a good field for selection work. 35/244, although possessing good lint characters, shows uniformity in a lax style of plant growth, which inclines to lodge. B 38/2 and B 38/9 are two of its more promising progeny.

3. A few other selections from Local, made in previous seasons, notably 36/56, 37/150 and 38/66 showed promising field characters. Four strain trials, in which comparisons were to be made between " Local," 35/553, 35/244, and 35/347, 35/566, BP 50, BP 52, SP 102, SP 84, Mz.561, Mz.457, 998R and 7L6 were planted. Three of the trials, planted about the end of March, are regarded as failures.

Results from the fourth trial are given in Table II.

TABLE II.

Strains.	566.	*Local.*	553.	244.	347.	*BP*52.	*Mean.*	*SE.*	*Sig.*	*Diff. P*=·05.
Yield of seed-cotton—per acre, lb. ...	254	251	245	223	197	153	220	20		58
In per cent.	115	114	111	101	89	69	100	9		26

On these low yields, Local and all selections from it, except 35/347, gave better yields than BP 52. With the possible exception of the difference between 35/566 and 35/347 there were no significant differences between any of the " Local " strains.

Entomology.

Cotton Stainers were present just before flowering in both the main fields of cotton, one planted at the beginning, and the other towards the end of March. Total populations of all species were approximately one adult to every two or three plant hills during the time that the young crop was being made. Adult populations increased in numbers

at the start of boll-splitting ; and peak populations amounted to about 3–5–8 adults per plant hill over the period that the crop was opening.

In the land which was planted in early March, *D. cardinalis* was at first the most numerous species in the crop at the time that the plants were starting to flower ; but the numbers of *D. fasciatus* equalled and then surpassed *D. cardinalis* during the green boll stage. The numbers of *D. fasciatus* increased markedly about the time that the first bolls split.

D. intermedius was always present in small numbers; a very few specimens of *D. nigrofasciatus* were also taken.

Callidea and *Nezara* were observed in small numbers in the January-planted observation plot.

The damage done by the stainer populations described above was severe, particularly so in the crop planted in late March, although total populations in this field were smaller than in the crop sown in early March.

It is probable that on this Station stainer attack may cause serious damage to the seed of the plant-breeding material in certain seasons.

The area carries a fair population of baobabs and other wild food plants of the pest.

American Bollworm.—Except in one corner of a particular field, American bollworm did little damage to cotton this year. The field where marked damage did occur lies near the river, where maize had been established early in the season ; there were no other areas of early-planted maize. As all tree and bush growth along the river has been cleared in recent months as an anti tse-tse fly measure, it is expected that the banks of the river will be used increasingly by natives for growing early-planted maize, and other crops on the short rains. This area, therefore, might possibly serve as a breeding-up ground for American bollworm before the cotton-planting period in March.

Jassid was present in the main crop from the early stages of plant growth. Populations appeared to remain small, and they caused little damage to the plants.

Miscellaneous.

It has been a very difficult season for the agriculture of the peasant farmers in the Settlement ; their easy-going methods of farming are not framed to take advantage of scant rains such as were experienced this year at planting-time. They will in future have to be encouraged to prepare their lands in good time ; and it will be necessary for them always to maintain, in every season, a high standard of agriculture if crop failures in like seasons are to be minimised.

As cattle and mixed-farming are essential to the scheme of settlement, twenty heifers are at present being given to various peasants.

The clearing of *all* tree and bush growth in the area as a whole, but more particularly along the course of the Ngerengere River in the Settlement, is being rapidly accomplished. By so doing it is hoped that cattle may be kept throughout the settlement with a fair degree of safety from infection through " fly."

Summary and Conclusions.

Climatically the season was the worst on record. Owing to scant rainfall in March and April, the main planting months, neither food nor cash crops could be established efficiently. The peasant farmers, with their low standards of agriculture, were particularly hard hit by the unfavourable conditions. The need for higher standards in their agriculture is emphasised.

Results from various trials indicate that yields of cotton may be increased appreciably by (*a*) applications of compost, and (*b*) adopting a closer spacing between plants in the row. Bearing in mind the difficulties of this past season, it will be necessary further to test the spacing variables in future seasons. No harm will be done, however, if the principles of mixed farming with cattle, compost making and its use, are taught immediately.

Cotton seed stocks suffered severe damage through stainer attack. Last season, too, seed stocks were reduced by jassid and American bollworm damage to the crop. Plant-breeding work has therefore been hampered in the past two seasons. The results of one strain trial are reported; briefly, there were no differences in yield between five " Local " strains, but all of these were better yielders than B.P.52.

Of insect pest damage, that due to stainer was by far the most important this season; it was severe. Baobabs and *Sterculia appendiculata* are common features of the Kingolwira landscape.

PROGRAMME OF EXPERIMENTS FOR 1942.

As a result of extensive travelling done recently by Mr. Bebbington and myself throughout the Eastern Districts, it is apparent that general environmental factors (climate, soil and insect pests) at Kingolwira are not representative of those factors in the main cotton-producing areas. It is therefore hoped that it will be possible soon to make a start with establishing District Plots in the different areas. The work at the sub-stations will be primarily investigational in character—as

distinct from demonstrations. And the first factors (variables) to be tested will be strains of cotton, different spacings, and times-of-planting.

General circumstances connected with the organisation of this work must determine what other factors may be investigated, but it is hoped that it will be found possible to make a start with routine recording of the incidence of the more important insect pests of cotton, in certain areas.

On Kingolwira Station work will be as follows :—

1. Investigations on the yield potentialities of various soil types with cotton, compost, and spacing as variables.
2. Second-year effects on maize and/or sorghum following this season's compost experiments with cotton.
3. Plant breeding work with cotton.
4. Work on insect pests as time permits.

NYASALAND

COTTON EXPERIMENT STATIONS, PROGRESS REPORT FOR THE SEASON 1940-41.

BY

H. C. DUCKER AND W. L. MILLER.

INTRODUCTION. (H. C. DUCKER.)

At the time when the 1939–40 Report was written, it was not considered possible to give a detailed programme of work at the Main Experiment Station for the 1940–41 season, owing to uncertainty regarding future calls on the staff.

The entire Nyasaland staff had been, and still is, seconded to the Department of Agriculture, but Governmental requirements have necessitated the departure of only one member of the Plant Breeding and Field Experiments Section from headquarters. The remaining two members of this section were able to continue to reside at Domira Bay, and, in addition to outside work done for Government, were able to undertake a fairly full programme of work at the Station.

Both the Domira Bay Station, and the areas served by it directly, had a good cotton year within the limitations set by the rainfall, and the continued success of the close season measures permitted good average yields to be obtained.

The paramount importance of the insect pest problems in the Lower River areas has lead to the Chiromo Sub-Station being devoted entirely to the needs of the Insect Pest Control Section.

Of the two members in this Section, Mr. B. L. Mitchell has continued to work at Domira Bay, while Mr. E. O. Pearson moved to Blantyre, in order that he might more easily concentrate on the Lower River problems.

The Progress Report by the Insect Pest Control Section, which deals also with meteorological conditions in the Lower River areas and with the Chiromo Sub-Station, is given at the end of this Report.

METEOROLOGY.

The total rainfall for the season at Domira Bay was 31·37 inches, slightly under average, but the distribution was unusual.

After an unreliable planting rain in mid-December on which some food crops were sown, hot dry weather returned and the true planting

rains did not commence till January 2nd. When the rains did come their subsequent distribution was fairly good, but they closed abruptly on April 6th. The station therefore experienced the latest start, and one of the earliest finishes to the rains, so far recorded.

Other parts of the Central cotton areas of Nyasaland, which Domira Bay represents, were not so fortunate as the Experiment Station, and in general, but especially in the southern part of these areas, the rains were short in amount and curtailed in distribution.

Domira Bay Station.

Agriculture.

Cotton.—In 1940, a very large series of lint samples, for laboratory and spinning test, and for brokers' examination, were sent to England, in an attempt to reduce the large number of high-yielding varieties, strains, and crosses, which had accumulated, by eliminating all below a certain standard of lint quality.

Since there was some doubt regarding which would survive this elimination, it was decided to plant the entire bulk cotton acreage in small plots, mainly about $\frac{1}{2}$-acre each, comprising the entire collection of cottons.

Yields ranged from 374 lb. seed-cotton per acre for the lowest yielding variety, N.17 from Uganda, to 738 lb. seed-cotton per acre for the high-yielding U.4×Cambodia×U.4 cross, H.K., derived from stock supplied by Dr. Harland some years since.

The most frequent yields were 500 to 600 lb. seed-cotton per acre, and grade was excellent throughout, 95% being clean and white.

"920," the main straight U.4 type now in cultivation at Domira Bay, gave 534 lb. seed-cotton per acre.

These yields may be considered good in view of the very short period in which crop could be made, and the effectiveness of the close season measures, now faithfully observed for four years in succession, is again manifest.

A small bulk trial, similar to that of 1939–40, was planted, but suffered a grievous loss of stand from termite attack. Results were generally comparable with those obtained in last year's experiment, but it seems doubtful if much reliance can be placed on intra-strain differences, even with the use of co-variance adjustment of yield on stand. Strain differences so adjusted were in the same order as in 1940.

The difficulty with termites appears to be inherent in the rotation cropping practice used hitherto on the Station, wherein cotton

immediately followed two years' rest under pigeon peas. Stand counts made systematically throughout the season in Break I (cotton following pigeon peas), and in Break III (cotton following groundnuts) showed that the damage done in the former was ten times as great as that done in the latter. Provisionally, therefore, the main rotation is being adjusted to permit of a hoed crop (maize) being planted prior to the first break of cotton. It is hoped that this alteration will result in some diminution of termite damage to the cotton, by starving out the pests in the dry season following maize harvest. The main rotation is therefore becoming a seven-course as under :—

Break I. Maize.
Break II. Cotton.
Break III. Groundnuts.
Break IV. Cotton.
Break V. Maize under sown Pigeon Peas or other rest crop.
Break VI. Rest.
Break VII. Rest.

This modification brings the balance of crops on the Station nearer to that favoured by the native grower, and will help in feeding the non-producing staff, recorders and other workers, now augmented in number by the increase in Insect Pest Control activity.

A standard strain trial, planted in a field of Break III in the unmodified main rotation suffered hardly at all from termite attack. Stands were good and the following results were recorded :—

	Yields in lb. seed-cotton per acre.	
H.K.–2	738	
N.H.–7	634	
H.L.–4	625	
H.M.–13	575	
" 561 "	562	Significant difference
" 920 "	523	=114 lb. (P=0·01)
N.C.–4	520	
S.P.84	513	
Crown Land Bulk	486	
N.17	420	

The poor showing of N.17 was due largely to its susceptibility to jassid, a severe attack of which was experienced at Domira Bay this year. The relatively good performance of " 561," a cotton selected by Mr. D. Thornton at Ukiriguru in Tanganyika, is noteworthy.

The cultivation experiment with cotton did not show statistically significant differences between treatments this year, but it is interesting to note that five out of the six leading treatments were ridged plots.

No cotton plots occurred in this year's breaks of the rotation

experiment, but in 1941-42 all plots will be sown to cotton, and it is hoped *inter alia* to make a special study of the incidence of termite attack.

Rotation Crops—General.—Maize took its place in the duplicate cultivation experiment this year and the difficult planting conditions provided some interesting comparisons.

Stand counts made in January showed highly significant advantages in digging fully, as compared with strip digging, and of both diggings over no pre-cultivation. Also, rather surprisingly, for late clearing of plots as opposed to early clearing. The native practice of delaying the clearing of old garden land to the last possible minute is usually ascribed to laziness! Final yield figures confirmed these differences, both satisfying the F test with P=0·01.

A similar advantage for digging was demonstrated with groundnuts last year, but in not digging his land the native does not follow normal Station practice with maize.

Nothing of particular interest was noted in the yield results of the rotation experiment; maize and sorghum were the only crops planted in this experiment this year, but the up-rooting of elephant grass, compared with clearing a pigeon pea and weed cover, proved rather laborious for hand labour. Experiments, to discover the most effective way of dealing with this otherwise admirable rest crop, will be planned.

Maize.—Though patchy stands were obtained with the December rain, it was not until the real break of the rains in January that the crop came away.

Final yields were the lowest so far recorded on the Station, averaging for the 25 acres added to the main rotation in 1938–39, less than 1,600 lb. per acre. This area had been formerly in native cultivation for at least fourteen years, and though last year good crops of cotton were obtained from it, the fertility is too low for maize in a dry year.

The only field to yield up to the usual Station standard had been in the main rotation for several years. This gave 2,700 lb. per acre.

Fortunately the poor fields go to rest now for two years under pigeon peas, which will enable them to recover their fertility.

It has been decided to modify the high-yielding bulk selection of native maize used as the Main Station stock by crossing with yellow-seeded varieties, of higher carotene content, thereby improving its nutritional value to our labour force. With this in view, seed of Peruvian Yellow bulk, and of "streak resistant" Peruvian Yellow,

has been obtained from Barberton. A stock of Chester County Yellow Dent, supplied by the Department of Agriculture, Makwapala Agricultural School, has also been obtained.

Simple crossing technique, followed by mass selection, will be used.

Groundnuts.—This crop did well in spite of a difficult start, and gave a mean yield of well over 1,500 lb. per acre unshelled nuts. Gambia Bunch was used on the bulk of the acreage, the Station collection of varieties being carried on in small plots. This Station seed stock of Gambia Bunch is in keen demand throughout Nyasaland. Many more tons than were available could have been sold. Most of the Station surplus was disposed of for seed purposes.

An experiment has been begun to ascertain how many years should elapse between crops of groundnuts on the same field, and the most effective cropping procedure in the intervening period. This experiment is really an extension of the large-scale rotation experiment now approaching its close. Reference to the depressing effect of groundnuts following groundnuts was made in the 1939–40 Report.

Pigeon Peas.—The unfortunate results with pigeon peas in 1939–40 have not been repeated in the same measure, the 1940 sowings coming through the dry weather far better than those of 1939, though still on land which had previously carried this crop. Those of 1941 are on new land and show no disease or die-back at all. The elucidation of the cause of the 1939–40 trouble must await its recurrence.

Elephant Grass.—In 1939–40 a 2½-acre field was utilised for an experiment on the best times of planting and spacing this grass when inter-sown in maize. There is now an excellent cover in this field over all plots, and the ease with which this grass may be established on non-flood land at Domira Bay is confirmed.

When it is decided to return this field to general cultivation it will be utilised for uprooting experiments, using various techniques. The native practice is to weaken the grass by hoeing it down several times, burning the trash as it dries, after which the land is dug.

A further 2½-acre field is to be used for experiments with pure stand elephant grass sown under maize in comparison with an elephant grass–velvet bean mixture. This is in imitation of the *Hyparrhenia* spp.–*Stizolobium* sp. (Itch bean) mixture which occurs naturally on dry land in the bush.

Miscellaneous Crops.—As usual a range of these was planted in odd fields, outside the main rotation. There is nothing of note to report concerning them.

Genetics and Breeding.

As with the cotton bulks, it was decided to plant the entire Station stock of breeding material in order to be able to carry on with any lot or lots which spinning and laboratory tests at the Shirley Institute might prove desirable.

Two five-acre fields were used for this material, and plots for the most part were 1/20th acre in area. Both natural and selfed seed of every variety, cross and strain was harvested and stored.

In addition to the older material, 178 single-plant selections from the 17 Crown Land bulks mentioned last year were sown in progeny rows. These were rigorously rogued for jassid susceptibility, and later, when bolls opened, for lint quality. 36 lots were eventually retained, the natural and selfed seed-cotton of each being harvested separately. The lint of 26 of these survivors, which all ginned at 32% or better, was sent to England for examination and report.

N.17 from Uganda, and " 561 " from Tanganyika, were both grown isolated from one another and from other cotton in 5-acre bulks. The generally poor resistance to jassid of N.17 made it suitable only for single-plant selections. 68 of these, which combined apparently satisfactory jassid resistance with lint of good quality, were harvested.

" 561 " proved to be an altogether better cotton than N.17 from an agricultural standpoint, and was harvested both as mixed bulk and special bulk, the latter from a carefully rogued ½-acre, and from it 72 single-plant selections were taken.

Spinning tests carried out by the Shirley Institute on 1940 crop lint samples were in direct confirmation of previous results, and showed that " 920 " and its derivatives are the outstanding cottons among the older stocks at Domira Bay. Unless " 561 " proves decidedly better than " 920 " it seems likely that the latter cotton will remain the Main Station stock for some time to come.

" 920 " appears to be a satisfactory substitute agriculturally for the present Crown Land bulk, and it is slightly superior in spinning quality to the best of the Crown Land bulk lots sent for trial last year. The latter incidentally made a very good showing in the tests, which augurs well for selections from them.

It would appear, from comparisons with Barberton, that the Domira Bay version of " 920 " bulk and the parent stock at Barberton differ slightly. Nyasaland appears to produce coarser lint and a lower maturity than does Barberton. To determine whether this difference is genetic or environmental, parallel trials of Domira Bay and Barberton " 920's " have been arranged for 1941–42 at both Stations.

It has to be reported with regret that the highest yielding cotton

on the Station, the H.K. cross, has proved to be a poor spinner in all its versions, and must therefore be discarded.

The crosses H.L., N.H., and the Nyasaland equivalent to H.K., our N.C., all show a certain amount of promise, and work may be resumed on them if lint of better quality than that of " 920 " cannot be reconciled with good yield.

S.P.84 was a disappointment, both as a cropper this year and in the spinning tests, where it merely equalled Crown Land U.4. It is to be feared that for Nyasaland conditions this variety is no better than its parent U.4/4/2.

One very interesting point arose in the spinning test on the Nyasaland version of S.G.27. This cotton, which was well liked by the brokers on account of its good length, disappointed as a spinner. being not so good as the shorter " 920 " and barely equal to a poorish Crown land sample. It appears, from the Shirley Institute laboratory examination to be far coarser than would be expected from its parentage. It seems possible that the eight years of re-selection to which this cotton has been subjected may have some connection with this coarsening of lint; jassid resistance may have been built up at the expense of quality.

A commercial bulk of " 920 " was tried out on an estate in the Dedza Lake-shore area with satisfactory results. A ratio of 8 tons of seed-cotton per ton of seed issued being obtained.

The bulk seed now available is to be further increased on another estate near Salima next season, with a view to replacing with it Crown Land stocks in this srea.

Spinning test material sent this year for trial consists of N.C. " 920," N.17, " 561," and Crown Land selections.

Crop Development Studies.

In co-operation with the Insect Pest Control Section, the system of tagging flowers and recording their subsequent fate was continued.

A randomised block experiment comparing 1 and 3 plants per hole was again used, but this year the 3-plant plots were significantly superior throughout in flowering rate, and subsequently in final yield. The tag records show that the chance of a flower developing into a ripe boll was better in the 1-plant plots, but this season there was no difference in the percentages of seed-cotton, clean and stained. There was about 95% clean in each case.

90% of the final crop in the case of the 1-plant plots, and 91% of the crop in the 3-plant plots came from flowers tagged in the five weeks ending April 8th. No flower tagged later than this date became

a ripe boll. Results were therefore similar to those of the 1938–39 season, and for the same reason, an early cessation of effective rain.

Summary and Conclusions.

Results this year at Domira Bay and in the areas which it represents continue to confirm the suitability of these areas for " summer crop " cotton, sown at the break of the main rains.

The close season measures for the control of insect pests were again a success, for the fourth year in succession, at the Station.

Work on " 920 " has continued satisfactorily, and a new series of " quality " selections of various parentage is well on the way.

A possible rival to " 920 " has appeared in the Tanganyika cotton " 561," but further agricultural experience with this cotton is required, as well as detailed knowledge of its spinning qualities.

Work on agricultural problems connected with cotton continues to progress satisfactorily, and the solution of certain basic problems in rotation cropping practice may now be in sight.

PROGRAMME OF EXPERIMENTS, 1941-42 SEASON.

Cotton.

Standard Strain Trials.—Domira Bay " 920 " and its derivatives are to be compared with Salima Crown Land Bulk, " 561," Barberton " 920 " and a selection (0268) made from the latter at Barberton. A parallel experiment will be done at Barberton in which Domira Bay versions of " 920 " will be compared with Barberton stocks, and spinning test samples will be sent to England from both Stations.

Small Bulk Trials.—The new Crown land selections are to be compared with " 920," " 561," and " 561 " special bulk, using the method devised by J. B. Hutchinson.

Increase Plots.—" 920 " Domira Bay bulk, six Domira Bay re-selections from this cotton, and " 561 " are all to be multiplied for further commercial trial.

Breeding Plots.—Selfed stocks of the " 920 " re-selections, single-plant selections from N.17 and " 561," and selfed stocks of the Crown Land Selections will be sown in these plots.

Rotation Experiment.—All plots in this experiment will be planted with " 920 " Domira Bay bulk, for an initial comparison of the treatment effects.

Rotation Crops.

Maize.—Pure stand and mixed sowings (for crossing) will be made of Domira Bay selected native bulk, Peruvian Yellow bulk, Peruvian streak-resistant bulk, and Chester County Yellow.

An interplanting experiment, to ascertain the reactions between maize and groundnuts so treated, will be included in one of the maize bulk fields.

Groundnuts.—The long term experiment to find out the best way of including this crop in a rotation will be continued. Bulk sowings of Gambia Bunch will be made, and the collection of varieties maintained in small bulk.

Elephant Grass.—A new experiment wherein this rest crop will be compared in pure stand and inter-sown with velvet beans will be laid down under maize.

Work for Insect Pest Control Section.

A special plot of 3½ acres of cotton, treated in Native fashion as regards its cultivation, is being provided for pupal mortality studies on *Diparopsis castanea* Hmps., Red Bollworm. Also an irrigated plot of cotton to provide out-of-season feeding material for the insectary.

The remainder of the Insect Pest Control field experiments will be done in suitable parts of the Main Station rotation.

ENTOMOLOGICAL WORK.
PROGRESS REPORT

BY

B. L. MITCHELL and E. O. PEARSON.

The Lake Shore Area (B. L. MITCHELL).

Routine Field Records.—Red bollworm (*Diparopsis castanea* Hmps.) egg and larval field populations have been recorded in a similar manner to previous years. The late break of the rains must be regarded provisionally as having been responsible for the two weeks' delay in emergence of moths from 1940 diapausing pupæ. Apart from this difference, moth flight and oviposition were essentially similar to previous years. The peak of oviposition from the diapause section occurred in the second week in March as compared with the end of February in previous years, whilst the first generation took the usual eight weeks to develop.

Routine Pupation Work in Protected Cages.—These results have again been similar to previous years. They are being continued using larger numbers and we shall shortly be in a position to analyse more intensively all results to date.

The results of all the following experiments relating to pupal diapause are necessarily incomplete since many pupæ under observation will not emerge for another four to five months.

For the purpose of this Report a "short-term" pupa is one which commences development immediately after pupation. An "over-winterer" is a pupa whose development is initially retarded during the cold weather but which commences to develop between July and September on the advent of warmer weather. A "diapauser" is one which lies dormant over yet a further period spanning the hot dry weather, and does not commence development until after the break of the rains. In nature, on the Lake Shore, these groups are distinct except for a slight mergence of the short-term and over-wintering groups. A "non-developer" is any pupa which has not yet commenced to develop. It may subsequently emerge as an over-winterer or as a diapauser as it is not yet possible to distinguish between the two before development actually starts.

The Effect of Larval Food on the Length of Pupal Life.—Larvæ were fed from hatching to pupation exclusively upon food of known age. Five food groups were taken based upon Rainey's analysis of fruits throughout growth as published in the Progress Reports from Barberton for 1938–39 and 1939–40. The classes ranged from very young buds to five- to six-week-old bolls. Moths from short-term pupæ and over-wintering pupæ were obtained from all groups, but results in length of pupal life were masked by two factors, uncontrolled temperatures and the small number of moths obtained in each treatment. It is hoped to repeat this experiment in controlled temperatures and with improved technique in 1942. It appears that development of the larvæ is most rapid and the resulting pupæ formed are largest when fed upon bolls of one to two weeks old. Growth of larvæ on small buds is very prolonged and the resultant pupæ minute.

Effects of Different Humidities on Length of Pupal Life.—Large numbers of field-collected, full-fed larvæ have been allowed to pupate in the insectary and subsequently transferred to controlled humidity chambers. The humidities chosen were 100% over distilled water and 75% and 50% over glycerine solutions. The humidities cannot be regarded as constant since no means are available of controlling temperatures; however, a range of humidities is obtained varying slightly round the given means.

Humidity can be ruled out as a factor affecting length of pupal life in short-term and over-wintering pupæ, though emergence of long-term pupæ is not yet complete. Humidity, again, has no effect on the proportion of pupæ entering diapause.

Comparison of Length of Life of Naked Pupæ and those in Earthen Cells.—There was a suggestion, in the preliminary humidity experiments carried out in 1940, that naked pupæ tended to emerge or die sooner than pupæ in undamaged earthen cocoons. This might be due either to the heat insulation effect of the cell, containing as it does a considerable volume of still air, or to a carbon dioxide accumulation effect. If the temperature lag were the cause, then the maximum temperatures obtained during the day would fail to reach and stimulate the pupæ to development. This has been tested by large parallel lots of exposed naked pupæ, of naked pupæ blanketed by half-an-inch of loose soil, and of sound pupæ in their undamaged cocoons. The effect of removing the cocoon is to shorten the pupal life by a very small amount, a few days, in short-term pupæ, and by a considerable amount, two weeks, in over-wintering pupæ. Its most striking effect, however, is to transform would-be diapausers into over-winterers so that the emphasis in the proportions of these two groups is reversed. The effect of blanketing with loose soil is intermediate between the other two treatments suggesting that a temperature lag is the key to the problem, as the diffusion of carbon dioxide should not be seriously impeded by half-an-inch of loose soil. This requires further investigation by direct temperature measurements within the cocoon and by incubating the two groups at constant temperatures.

Continuous Measurements of Pupal Weight and State of Development Throughout Life.—It has been found possible to apply to *Diparopsis* a similar scale of pupal development to that observed in *Heliothis* in 1938 at Barberton. The fat body of a nearly-formed pupa is grouped in rounded lobes arranged in definite tracts about the pupal abdomen, the heart line is clearly visible and the eyes are a similar colour to the rest of the pupa. The first sign of pupal development is histolysis of the larval fat body into a mass of minute free granules which form a uniform hypodermal layer throughout the abdomen except in the cardiac region; this stage is followed closely by a pigmentation of the eyes. The next stage to be observed is the obliteration of the heart line and a general whitish opaque appearance setting in over the entire pupa. This is due to the formation of the imaginal cuticle and scales which commence pigmentation some thirty-six hours before emergence of the moth. This being readily visible in the living pupæ, it becomes possible to study them throughout their life and to know

definitely when development commences and diapause ceases. Some 350 pupæ have been reared in controlled humidities, weighed and examined weekly throughout life from pupation to emergence.

Non-developing pupæ lose weight fairly steadily and very slowly, with little difference showing between those in 50% R.H. and those in 100% R.H. The loss is of the order of 0·25 to 0·5% per week.

Developing pupæ lose weight rapidly, the rate of loss being governed by the humidity, but apparently not being proportional to it. The rate of loss is at first small, but increases rapidly and progressively to emergence. There is a suggestion that short-term pupæ lose a greater weight than is lost during the developing period of pupæ that have overwintered, but this may be due to a temperature effect since the experiment has been carried out without controlled temperatures. These results bear out those obtained in the large-scale experiment on effects of different humidities on pupæ, as the possibility of diapause being due to an early desiccation of the pupæ is ruled out since loss of weight in non-developing pupæ is small right from the start.

Pupal Water Contents.—Uniform collections of pupæ are being kept under field conditions at Salima and Makanga and another series subjected to different controlled relative humidities in the insectary. Samples are being withdrawn at fortnightly intervals for moisture content determinations and are being subsequently stored for fat determinations, etc., after the war. In the insectary series the regular sample contains only non-developing pupæ. Those which begin to develop are left until within 48 hours of emergence when their moisture content is determined. In all treatments the moisture content of non-developers is maintained at about 60% throughout their non-developing life. The moisture content of developing pupæ however tends to increase, rising to about 68% in 100% R.H. and 62% in 50% R.H. This strain in pupæ developing in low humidities must be regarded as accounting for the appreciable mortality which occurs at emergence in 50% R.H., many moths being unable to free themselves from the pupal shell and also unable to force an exit from their earthen cocoon.

Tolerance of Non-developing and Developing Pupæ to Waterlogging. – Submergence under water of non-developing pupæ even for a period as long as four weeks during July has little effect in inducing mortality, nor at this time of the year has it any effect in causing the breaking up of dormancy. There appears to be some retardation effect in that the longer the pupa is submerged the longer will it be before development actually starts. The delay appears to be something of the same order as the period of submergence and may still be noticeable many weeks

after the actual submergence. However, only a small number of moths have as yet been recorded in this experiment.

When developing pupæ are submerged, development is arrested at whatever stage they have reached at the time of immersion. If the pupa survives submergence, development is recommenced and successful emergence takes place. Mortality for three days submergence is nil, for five days 60% and for seven days 90%. It is doubtful if any pupæ would survive nine days under water.

These delaying effects of submergence may account for the lack of moth emergences in nature during very wet periods and may possibly have some bearing on the March, April and May emergences of diapausing pupæ.

A number of non-developing pupæ were submerged for a week during August and weighed daily to ascertain whether any increase in weight due to taking up of water occurred. One pupa actually did increase in weight, began to develop and promptly died; all others maintained constant weights.

The Effect of Short Submergences on Break-up of Diapause. –In order to see whether the flush of emergence which occurs in nature at the break of the rains can be anticipated artificially, a large number of pupæ which have over-wintered under field conditions are being treated to three-day submergences during the period September to November when development is suppressed in nature. Emergences in this experiment have hardly commenced.

Comparison of Length of Life of Pupæ found in Loam and in Sand.— To ascertain whether the type of soil in which pupation occurs influences the length of the pupal life, parallel lots of larvæ were allowed to pupate under field conditions in loam and in sand. The sand produced only half as many over-winterers as the loam.

To ascertain the Importance of Soil Moisture at Time of Pupation.— Large numbers of larvæ were collected at the end of June, half being allowed to pupate in moist soil, half in air-dry soil. Emergence to date shows no difference, but the experiment was begun in the coldest week of the year and it is possible that low temperatures masked the effects, if any, of soil moisture.

Discussion on Diapause.—A considerable number of data have now been accumulated concerning diapause, some of which may be briefly reviewed.

From evidence obtained this year from the weekly examinations of living pupæ it is evident that by the time the pupal stage is reached the individual is already destined to become either a short-termer or a non-developer. It is apparent then that the decision of short-termer

or not is taken, as in *Heliothis*, during the larval or pre-pupal life. We know from field evidence that both on the Lake Shore and the Lower River diapausing pupæ are formed during the dry months of the year. These dry months are, for the most part, cool, but from pupæ formed in the coldest month in the year, July, only 50% of recorded emergences are diapausers in the Lower River areas, whereas in September and October, when the weather is definitely hot but dry, about 70% of emergences are long-term. On the Lake Shore, which is considerably cooler than the Lower River, over 50% of pupæ going down in May and June go into diapause.

There are three factors, any or all of which may play a part in stimulating the formation of non-developing pupæ. These are low minimum temperatures, nutritional factors, and the effective moisture content of the soil during pre-pupal life. This last factor may easily play an important role, since the pre-pupa has to form a large hard earthen cocoon which it must do by using up the surplus water within its body in macerating the soil into a paste. It may readily be appreciated that it is far more difficult to form a paste from a dry soil than from a moist one or from a coarse sand than from a loam. It has been noticed that the size of cocoon is related to the moisture content of the soil and it is believed that the pupa itself bears a similar relation. Further, it has been noticed that pre-pupæ put down to pupate in soil of unknown, but very low, moisture content are unable to form a cocoon, and die.

On the nutritional side the evidence so far obtained is not good enough and this problem requires further investigation. This and a study of the effects of soil moisture on the pre-pupa will be undertaken in 1942 under constant temperature conditions. If further information is required on the effects of temperature on the larvæ a multiple temperature incubator will be required. It will not be possible to run such an incubator at Chitala since it requires a large daily supply of ice which would not be forthcoming.

For the break-up of the dormant stage, humidity or soil moisture may definitely be ruled out, from this year's experimental work, as being in any way responsible. The post-winter rise in temperatures is accompanied by a flush of moth emergence which in the field is again suppressed during the hot dry weather of October and November. Emergence recommences at the break of the rains. Under insectary conditions, where the temperatures are less extreme than in the field, the suppression of all development during October and November is not evident. This suggests that there exists a threshold of development temperature marking an upper limit to the range within which

development may start. It suggests also that there is no fundamental difference between over-winterers and diapausers.

Should the factors controlling diapause prove to be nutritional, then any control measures based upon an alteration of the planting and fruiting seasons of the crop are likely to be nullified by an alteration in the habits of the insect to fit into the new scheme. If, however, the factors are entirely climatic, such controls could be safely introduced based upon such evidence of the seasonal fluctuations of *Diparopsis* as we already possess.

Pupal Mortality under Field Conditions.—Unprotected pupæ have been placed under field conditions in order to observe what occurs in nature. One series was examined weekly and another examined at longer intervals. Apart from the usual ant predators, about a third of an acre has been cleared up by a nest of small mammals believed to be rats which have so far evaded capture. Their depredations commenced after the cotton was uprooted, when presumably their previous food supply failed.

Effects of Digging and Ridging on Pupal Mortality.—The cultivation experiment, in which are being compared the effects on yield of digging and no digging, ridge and flat cultivation, and early and late cleaning, was sampled immediately after the cotton uprooting in July, for density of bollworm pupæ in the soil. This will again be sampled in November to determine whether there is any difference in pupal mortality in the various treatments.

Plant development and crop loss were studied by the plant diagram method on plants with different degrees of bollworm infestation. The results have not yet been worked out.

For the first time since the writer arrived in Nyasaland (1938), there was a medium infestation of American bollworm (*Heliothis armigera*) on the Cotton Station during the latter half of April.

General and Lower River Districts (E. O. Pearson).

General.—The general policy outlined in our last Report, of concentrating upon the immediate problem of the Lower River cotton pests, was followed. In the past season the recording of the pest situation and of relevant factors has been continued, mainly in the Lower River. A certain amount of experimental and controlled observational work has also been carried out there. In order to facilitate this concentration of work in the Lower River, the writer transferred his headquarters from Domira Bay to Blantyre in December,

1940. Either end of the Lower River is conveniently accessible from the latter point and the arrangement has made for economy in travelling and a tightening of control of the recording work. The main work at the Domira Bay Station has consisted of experimental work on the diapause problem in *Diparopsis*, which we believe to be the key problem in bollworm control. Much advance has been made by Mr. Mitchell, who has been responsible for this work and whose report is given above.

In the Lower River, work has continued in the same seven selected areas. A census has been made in each of a small, compact area in which the history of all native gardens has been recorded (the number varying from 100 to 200), giving details of the crops grown and dates of planting. This has been necessary in order to obtain reliable statistics of the dates of planting of the cotton crop and of the extent, nature and dates of planting of the interplanted food crops, since upon these factors depend the whole timing and development of the cotton crop and its associated insect population.

Based on this census, selected gardens have been sampled continuously for insect populations, crop development and crop loss. This recording work has composed the greater part of the year's activities. A comprehensive set of meteorological records has been continued at all points and these records related to the eco-climate within the crop.

Pupation studies have been maintained. The method has been intensified and safeguarded: data from about twelve thousand individuals will be available this season.

The whole work of the Chiromo sub-station has now fallen on this section. Clearing has been extended and a long-term cropping programme planned. The work here centres on the time-of-planting experiment, whose general layout has already been described (Reports 1938–39 and 1939–40). This layout is partly experimental—that is to say, the yields may be used as a direct measure of the success of the various dates and methods of planting in that season's conditions. Its main value, however, is that by means of the detailed observations mentioned below, the factors governing such success or failure can be analysed amd the results of such analyses either applied to the actual performance of the commercial crop, or used to deduce what the effects of the adoption of any particular time or method of planting for the whole commercial crop would have been in that season. The detailed observations include (i) large scale taggings of flowers at regular intervals and analysis of the fate of the bolls produced; (ii) plant diagrams and bud marking to determine the production, location

and fate of all fruiting points ; (iii) the usual records of insect populations and flowering.

In addition, at Chiromo sub-station, the incidence and causes of mortality amongst red bollworm pre-pupæ and pupæ are now being studied, mainly in order that the results of the pupation cage work may be more accurately interpreted and due allowance made for such mortality in computing moth flight curves.

Continuous records of the life cycle of *Dysdercus fasciatus* and *D. intermedius* have also been started, under insectary and field conditions approximating as closely as possible to natural ones, mainly to explore the extent to which climate inhibits breeding at certain seasons.

One section of the programme given at the end of last year's Report could not be carried out, namely, the start of recording stainer populations on their wild hosts. It was not found possible to consider even the preliminary survey work until near the end of the season, by which time extreme drought conditions had reduced both stainers and their food supply to such small numbers as to make it difficult to train recorders to the work.

Weather Conditions.—The past year was an exceptionally dry one. The figures from Port Herald, which is at the extreme southern end of the Lower River, are given here, since this is the Station from which the longest series of records is available.

TABLE I.

RAINFALL, PORT HERALD.

Inches of Rain.

	Nov.	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Total*
1940–41	2·15	0·75	8·78	4·23	2·12	0·06	0·13	0·04	0·05	0·22	0·46	0·06	19·05
Mean of previous 16 years	3·24	7·88	8·07	5·64	6·16	2·12	0·40	0·85	0·62	0·57	0·30	0·75	36·60

Maximum temperatures were considerably above normal and minimum relative humidities were very low.

Patchy early rains fell in November, but December was very dry ; planting conditions were good during the first fortnight of January and again for 7–10 days at the end of that month and the beginning of February. Thereafter it became increasingly dry ; the March rains failed (March–April rains 26% of normal) and the cool season rains also failed (June–July rains 6% of normal). During the period that cotton was in the ground (February–September) only 6·06″ fell (mean of four stations), of which 1·29″ was in September.

The Shire River maintained a high level and there was no flood

land available for cotton. The greater part of the crop was planted in maize or millet.

From the point of view of field experiments the season was disastrous, since the influence of insect attack on plant development and crop loss was completely overshadowed in most plantings by the direct or indirect effects of the drought, leading to poor stands and growth. The experience has, however, been useful in that the reactions of the cotton crop and pests to an extreme limit of drought conditions have been thoroughly studied. Now at least we know the worst conditions which any proposed control measures would have to face.

Crop Statistics.—The dry conditions of November–December limited the early plantings of food crops and the garden census showed that over the Lower River as a whole, half the maize crop had to be planted in January. Virtually no cotton was planted before mid-January, but two-thirds of the crop was sown in the fortnight ended the 8th February. The remainder lagged on through February and March. The greater part of this remainder and a proportion of the main plantings failed to establish themselves, and it is estimated that only half the total gardens planted actually survived to contribute anything to the crop.

The statistics of the Department of Agriculture show that the number of gardens planted this season was approximately 5% less than in 1940 (18.577 against 19,599). The final production was 1,273 tons seed-cotton, of which 93% was No. 1 grade, as against 2,349 tons, of which 72% was No. 1 grade, in 1940. There was thus a decrease in yield over all gardens planted from 232 lbs. per garden in 1940 to 153 lbs. per garden this year. If, however, the fact is taken into account that actually only 58·7% of the gardens this year became sufficiently well established to contribute anything to the crop, the yield per effective garden works out at 261 lbs. per garden, which is actually slightly higher than last year's yield. Taking the figure obtained by the Department of Agriculture of 1·50 acres as the mean garden size this year, the yield per effective acre works out at 174 lbs. seed-cotton, of which 93% was No. 1 grade. This figure agrees tolerably well with that calculated from the weekly pickings from samples over the 28 gardens used for intensive recording this year, which gave an estimate of 198 lbs. per acre of which 92% was No. 1. This rather larger estimate will be due to the fact that the gardens selected for recording are rather better, in respect of stand, than the general run of gardens contributing to the crop. This choice is deliberate, since the advantages of taking a completely random sample of gardens is outweighed by the disadvantages of the waste of

time and loss of information in sampling those where stands are very bad. Within the chosen gardens, of course, sampling is strictly random.

These figures emphasise the fact that the shortfall in this year's crop was primarily due to failure of so large a proportion of the gardens to become established; where a stand was obtained at all the yield was up to last season's standard.

When the causes of crop loss are analysed it becomes clear how this rather surprising result was brought about. Of the total number of bolls which survived to a size where they were susceptible of examination (*i.e.*, those bolls which neither shed nor aborted in the first two weeks of their life), 30% were a complete loss due to bollworm*, 9% due to stainer, and 3% due to other causes, including physiological immaturity and direct bacterial disease; 58% contributed clean cotton.† The corresponding figures last year were: 44% bollworm, 30% stainer, 1% other causes, and 25% clean. There was thus a decrease of 14% and 21% in the percentage damage to the crop due to bollworm and stainer respectively.

If the actual gross production of bolls is considered, the difference between the two years becomes even more striking. The figures below are obtained from analysis of weekly sample pickings from all the sample gardens in both years.

TABLE II.

Comparison of Crop Production and Crop Loss, 1940–41.

Mean No. of bolls per acre (in thousands) produced or lost from various causes.

	Bollworm.	*Stainer.*	*Other Causes.*	*Clean.*	*Total.*
1940	49·0	29·3	1·0	25·5	104·8
1941	14·8	2·8	1·5	23·4	42·5

It will be seen that, in actual volume of damage, bollworm accounted for approximately one-third and stainer for approximately one-tenth of the damage done last year by these insects. Thus, in spite of the fact that gross boll production was more than halved, net production was maintained at about the same figure.

* Throughout this Report "bollworm" refers to *Diparopsis castanea* Hmps. Pink bollworm was conspicuously rare this year.

† For reasons which are given in the 1939–40 Report, shed and aborted bolls are not regarded as a main source of crop loss. The method of obtaining the figures given here is to examine all non-aborted bolls lock by lock, classifying the locks according to the nature and degree of damage suffered from the various causes. Bulk samples of these classes and grades are then re-graded according to the commercial classification (No. 1 and No. 2 grades, and unsaleable); in this way the economic value per lock of these classes can be worked out and hence a net yield and net loss in terms of equivalent clean locks obtained and converted into terms of bolls.

Crop Development.—The effects of the drought were threefold. In the first place much of the crop never became properly established. Poor stands of the inter-planted maize crop contributed to this, since normally the shading prevents the rapid drying-out of the seed bed. In the second place, much of the maize was planted in January and it was repeatedly observed that cotton in late-planted maize made very little growth. Presumably the crops come into direct competition under these circumstances, whereas in the ordinary way the maize is already senescent by the time the cotton is making any considerable demands on moisture and possibly nitrogen supplies. The effect, though more noticeable in dry years, seems important and is being investigated experimentally this year. The third effect of the drought was to force on the plant early in the season; this was accentuated by the generally poor stands of maize—over large areas the cotton approximated to pure stand. Growth was thus compact and flowering stimulated; in spite of the later planting this year, flowering and budding were earlier than in 1940. The accompanying graphs for flower production illustrate this point (Figs. 1 and 2).

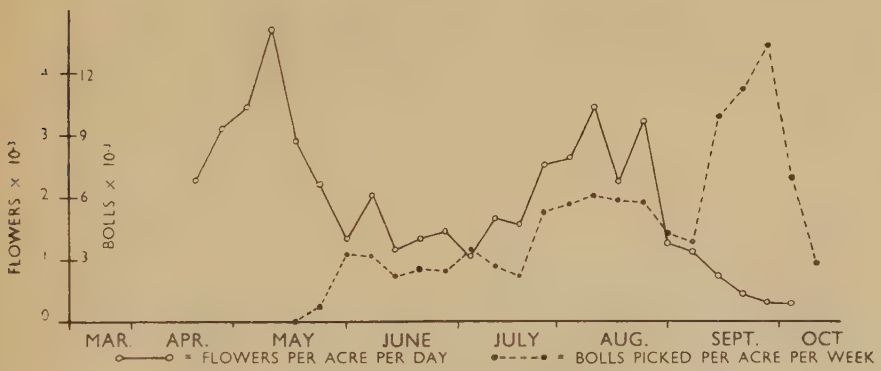


Fig. 1. Flowering and Bolling, Lower River, 1940.

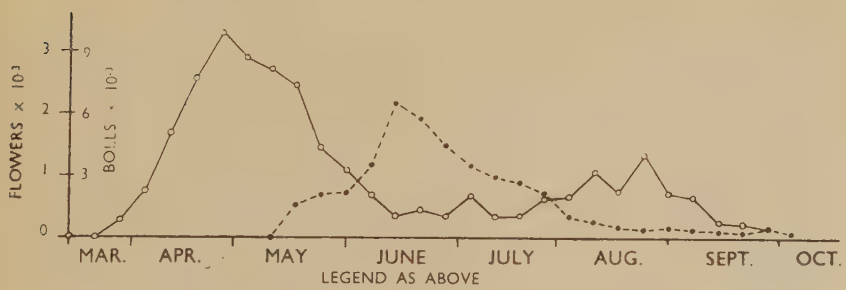


Fig. 2. Flowering and Bolling, Lower River, 1941.

The contrast as regards time of crop production is shown by the following table, giving the actual volume of production by months (*i.e.*, the actual number of non-shedding bolls harvested weekly, whether damaged or not).

TABLE III.
SEASONAL CROP PRODUCTION, 1940–41.

Mean no. bolls (in thousands) harvested per acre over all sample gardens.

	May.	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*	*Total.*
1940	3·9	10·5	19·7	22·1	38·6	9·9	104·7
1941	5·6	20·5	12·5	2·2	1·5	0·2	42·5

In 1941, 94% of the clean crop was harvested in May, June and July as against 11% in these months in 1940. If we look at the effects of the bollworm attack upon this early crop (Table IV), it will be seen that the actual volume of damage done by bollworm in the two years is about the same at this time, although later in the season the amount of destruction caused in 1941 is very much smaller than in 1940, there being, of course, far less crop to damage. The difference in the proportionate damage in the two years in May–July, however, is very striking, as is shown in Table V.

TABLE IV.
SEASONAL BOLLWORM DAMAGE, 1940–41.

Mean No. bolls (in thousands) destroyed per acre by bollworm over all sample gardens.

	May.	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*	*Total.*
1940	3·2	7·9	11·9	9·4	12·7	3·9	39·0
1941	2·4	6·5	4·0	0·9	0·9	0·1	14·8

TABLE V.
PERCENTAGE OF TOTAL BOLLS PRODUCED DESTROYED BY BOLLWORM.

	May.	*June.*	*July.*
1940	82%	75%	60%
1941	42%	32%	32%

The yield per acre has, in fact, been maintained by a more efficient production of bolls from an exclusively early crop in 1941, compared with a relatively inefficient production of bolls from a predominantly medium and late crop in 1940.

Bollworm Activity.—In spite of the very great difference in the character of the two seasons the same general phases of bollworm activity have been recognisable in 1941 as were outlined in the Report on the previous year. These may be recapitulated as follows :—

In the first phase, occupying the whole of March and April, bollworm egg-laying was at an extremely high level, due this year exclusively to moths emerging from the diapause fraction of the previous season's pupæ. There was a distinct trough in the egg-laying curve in late April–early May, separating this first phase from the second, which in turn is due to moths which have been bred up from the first phase.

This gives place in late June to the third phase, characterised by low moth activity and falling egg-laying which extends over the rest of the season. The fourth phase, observed in 1940, of recrudescent activity in late September, was only apparent this year in such gardens or experimental plots as possessed cotton in an attractive state at that time. Over the bulk of the crop the plants were by then completely senescent. The course of bollworm activity in the two years is shown in Figs 3 and 4. These, and the figures for crop development (Figs. 1 and 2) are based on mean weekly values over all the sample gardens.

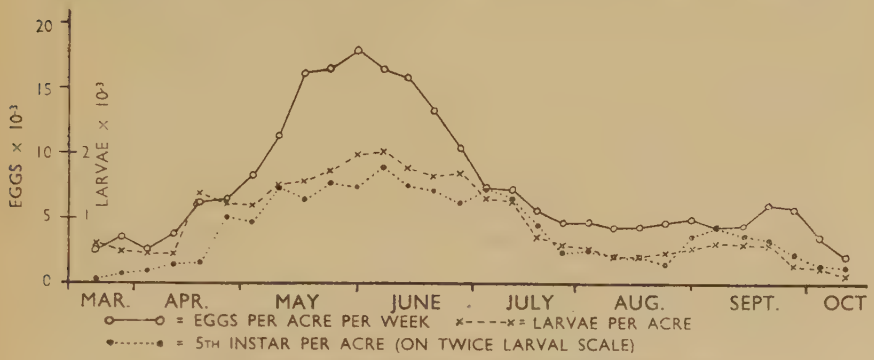


Fig. 3. Red Bollworm population, Lower River, 1940.

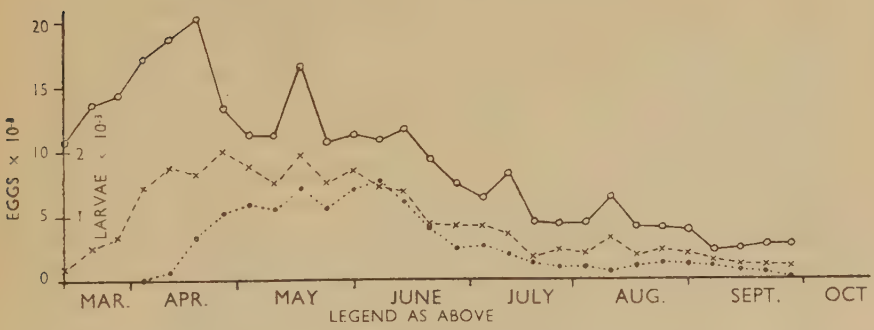


Fig. 4. Red Bollworm population, Lower River, 1941.

Whereas, however, in 1940, the peak of the egg-laying came in May–June, due to moths bred in the crop, in the present year the egg-laying in the first and second phases of moth activity was of the same order of intensity. Notwithstanding the fact that egg-laying in the first phase was nearly three times as great this year as last, the resulting larval populations were only slightly larger in 1941. Furthermore, despite the similarity of the larval production in the first phase in the two years, the egg-laying in the second phase was actually smaller in 1941 than in 1940, and the corresponding larval population distinctly smaller. In the third and fourth phases this

year's records for all stages are much below those of 1940. A rough summary of the position is given in Table VI below. These figures represent the average values per week over the whole of the areas sampled, totalled over all weeks included within each phase of moth activity.

TABLE VI.

SEASONAL BOLLWORM ACTIVITY, 1940–41.

Totals per acre in each phase (in thousands).

	Phase I. Egg-laying up to 3 May; larval pop. up to 10 May.			*Phase II. Egg-laying 10 May–28 June; larval pop. 17 May–5 July.*			*Phases III and IV. Egg-laying 5 July onwards; larval pop. 12 July onwards.*		
	Eggs.	*Larvæ.*	*5th Instar.*	*Eggs.*	*Larvæ.*	*5th Instar.*	*Eggs.*	*Larvæ.*	*5th Instar.*
1940	32·9	8·7	2·0	128·0	19·4	5·6	77·7	8·3	3·7
1941	96·7	11·0	1·9	81·3	12·3	3·9	55·3	5·5	1·6

Owing to a slightly improved method of egg recording used in 1941, by which the possibility of failing to record eggs is greatly reduced, the recorded egg populations this season may be up to 20% higher than they would have been had the old (1940) method been used. This should be allowed for in comparing the two years.

It has already been pointed out that the great bulk of the 1941 crop matured in May, June and July, mainly the two latter months. It is to the damage done to bolls maturing in this period that we should look for an explanation of the relatively low bollworm losses this year as compared with 1940. Table IV shows that this was rather less, in 1941, in bolls maturing in May–June, and distinctly less, in 1941, in bolls maturing in July. Bolls maturing in these months will have been exposed to bollworm attack from mid-March, but the critical period (taking into account the shape of the bolling curve and the period in the boll's life when it is susceptible to damage) may be taken as late April to mid-July. Over this period bolls will have been exposed to the attack of, partly, the first phase, but pre-eminently the second phase of bollworm activity. The smaller volume of damage in 1941 may thus be directly related to the diminution in size of the second phase, both absolutely and relative to the first phase, in 1941. Had anything approaching a normal rate of multiplication been attained, following the high initial infestation of 1941, the damage due to bollworm might have been from two to four times as large as it was.

The most obvious points of difference between the infestations in 1940 and 1941 are set out below.

(i) The number of eggs in the first phase is greater in 1941. Effective planting was later and more compressed in 1941 : this should have led to a smaller egg-laying through the evasion of a greater part of the

diapause flight and the elimination of any reinforcement of this flight by moths bred up in early plantings. Three factors offset these potential benefits. First, flowering was actually earlier in 1941, for reasons which have already been given. Secondly, the effective acreage was just about half of what it was in in 1940. Other things being equal, the egg-laying per acre should therefore be doubled. Thirdly, the size of the late crop (as estimated by taking the September–November market returns) in 1940 was about 1½ times that of 1939 and as we have good grounds for believing that under present conditions the bulk of the diapause generation is derived from pupæ formed on the late crop (see below, under pupation work), one might reasonably expect the 1941 diapause flight to be correspondingly higher than that of 1940. All told, then, a diapause flight per effective acre of approximately three times the size of that of the previous year might be expected, which is precisely the ratio of the first phase egg-layings in the two years.

(ii) In spite of the much greater egg-laying in the first phase in 1941, the larval population in this phase is not proportionately anything like as large. This suggests increased mortality in the early larval stages in 1941 ;* the ratio of the total larval to the total 5th instar population is about the same in the two years, suggesting no difference in mortality in the late larval stages.

Mortality between egg and larval stages is normally very high—our data suggest something of the order of 95%. This being the case, it only requires an increase of about 3–4% in this mortality to account for the failure of the greater egg populations of 1941 to produce equally greater larval populations.

It seems probable that the cause of such increased mortality in early larval life is the abnormally dry weather experienced this year in April–May. Bollworm larvæ are presumably most susceptible to climatic influence immediately after hatching, when they are moving about the plant in search of suitable food and before they have reached the comparative immunity from climatic variations afforded by the inside of the green bud or boll. Maximum saturation deficiencies were 29% greater and evaporation 57% greater during the first phase of bollworm activity in 1941 than in 1940.

(iii) The egg-laying in phase II is considerably less than in 1940 and as larval and 5th instar survival in this phase is of the same order in the two years (see Table VII), larval and 5th instar populations are also correspondingly less in 1941. This reduction in the egg-laying

* Egg mortality cannot be excluded ; we have no routine records of incidence of parasites and predators on the egg stage, though we know that this is normally slight and is unlikely to be favoured by drought.

in the second phase in 1941 as compared with 1940 cannot easily be explained by assuming merely that it was due to a smaller phase II moth flight. This moth flight is derived from the 5th instar populations of phase I, which are nearly the same in the two years. Moreover, if moth emergence from the pupæ formed by these larvæ is considered, such figures as we possess suggest that similar numbers of pupæ gave rise to similar numbers of moths in both years, *i.e.*, that there was no excessive mortality among, nor shift in the form of the emergence from, pupæ derived from the first phase of moth activity in 1941.

It seems more probable that this reduced egg-laying was due to lack of stimulus to, or direct inhibition of, egg-laying. Inhibition of egg-laying might be due to climatic effects restraining actual oviposition, or limiting adult life. It is possible that the severe climatic conditions of 1941 might have had such effects, but these conditions were equally, if not nore severe, in the first phase, when egg-laying was high. If we make the assumption that the presence of fruiting points (particularly buds and flowers) is an important stimulus to oviposition, it is possible that the discrepancy in egg-laying in the second phase in the two years is accounted for by the smaller bud production and flowering at this time of the season (May–July) in 1941. Further analysis of the data from the plant diagram work this year is required before a definite statement on this point can be made.

(iv) The decrease in egg-laying in the second phase of 1941 compared with that of 1940, leads to a proportional diminution in the populations throughout the rest of the bollworm year. The corresponding figures in the various phases and stages, with egg-laying in phase II reduced to 100 in each year, is given below. These figures are based on those of Table VI.

TABLE VII.

RELATIVE MULTIPLICATION OF BOLLWORM BRED IN THE CROP, 1940–41.

Egg-laying in Phase II reduced to 100.

	Phase II.			*Phases III and IV.*		
	Eggs.	*Larvæ.*	*5th Instar*	*Eggs.*	*Larvæ.*	*5th Instar.*
1940	100	15·2	4·4	60·7	6·5	2·9
1941	100	15·1	4·8	68·0	6·8	2·0

These figures suggest that, once the lower level of infestation in 1941 had been established by the shortfall in egg-laying in the second phase, the mortality and reproduction rates were very similar in the two years. The agreement between the two years is not actually quite as good as the above figures, since it will be remembered that egg populations tended to be under-estimated in 1940. To that extent the multiplication is better in that year.

The *absolute* diminution in 5th instar larval populations in the latter part of 1941, compared with 1940, is, of course, of the greatest importance, since it is from these that the carry-over population of diapause pupæ to the next season (1942) is derived. The prospects for a light infestation next year are therefore good.

Stainer Infestation and Damage.—The whole season was marked by very low stainer populations both on wild host plants and in the crop. The annual or semi-perennial herbaceous host plants *Hibiscus vitifolius* and *H. physaloides* were extremely scarce.

The stainer infestation in the crop followed much the same pattern as in 1940, but was of trifling size. Initial immigrations of adult *D. intermedius* started in late April and extended into June, with a peak population on 17–24 May. This initial infestation nowhere exceeded 250 adults per acre. Breeding was restricted and retarded, the peak of the 5th instar nymphal population produced rarely equalling the peak of the adult immigrant population and not occurring until early July. No adult population derived from this was recorded in the crop. As food supplies for young nymphs were this year plentiful throughout May (*cf.* 1940), the restriction in breeding must have been climatic.

D. fasciatus appeared at about the same time as *D. intermedius* and in even smaller numbers, building up a similarly small 5th instar population by early July. In contrast with *D. intermedius* the adults developed from this generation remained in the crop and under conditions of rising temperatures in August–September, succeeded in maturing populations amounting in some cases to one or two thousand adults and 5th instars per acre by late September.

Small infestations of *D. nigrofasciatus* adults were recorded during the season, but very little breeding followed.

In general these records confirm the suggestion made in last year's Report, that during the cool dry season stainer infestations are restricted by the climatic factor. They also confirm the ability, long observed in our South African records, of *D. fasciatus* to survive under more extreme climatic conditions than *D. intermedius*. The results of the insectary work started this year at Chiromo will be discussed when a full year's records are available.

The extremely small stainer infestation this year has resulted in a large increase in the proportion of clean cotton in the commercial crop. Bollworm attack is felt mainly as a complete loss of crop, *i.e.*, if a lock is attacked at all by bollworm it rarely produces any cotton which will contribute even to the No. 2 grade. Stainer attack, on the other hand, whilst resulting in a great deal of dead loss, comprises

the main contributing agent to the No. 2 commercial grade. The proportion of the latter may thus be taken as a fairly good indication of the stainer infestation—unless direct injury by bacterial boll rot is unusually common. Thus, along with the reduction in total loss due to stainer from 30% in 1940 to 9% in 1941 (or, taking the figures for absolute loss, 29·3 thousand bolls per acre in 1940 to 2·8 thousand bolls per acre in 1941), the percentage of No. 1 grade in the commercial crop rose from 72% in 1940 to 93% in 1941. The proportional reduction in the figures for absolute stainer loss and for stainer populations per acre in the two years are of the same order.

Time-of-Planting Experiment, Chiromo Sub-Station.—Much of the work here (mainly tagging and plant diagram studies on the time-of-planting experiment) was spoilt by the abnormal weather conditions. Unfortunately, with so long a season, extending from January to October, where there is always a chance of a bad start being retrieved by a good finish, all the recording and experimental work planned has to be carried through practically to the end of the season before it is safe to abandon any of it. In this case, however, the weather conditions persisted implacably to the end of the season, with the result that about four-fifths of all this work turned out to be a waste of time. Such results as have been salvaged will be held over for discussion until the whole series of experiments, which we plan to continue for another year, have been finished.

Pupation Work, Red Bollworm.—Pupation records from cages embedded at three points in the area have been continued. Much extremely valuable information continues to flow from this work, since, by using the data on the time of emergence of moths from weekly collections of 5th instar larvæ in conjunction with the field population records, it is possible to determine the form, dimensions and origin of the seasonal moth flight, particularly that part of it which constitutes the initial infestation of the new crop.

The diapause moth flight for the Chiromo district in the past season, constructed in this way, is given in Fig. 5. The total height of the ordinate for any date gives the total number of moths emerging per acre during the week ending on the date given. The month of origin of these moths (*i.e.*, the month in which the 5th instar larvæ from which they were derived were collected in the field) is indicated by the shading of the ordinate. For example, in the week ending 22 February a total of 87 moths per acre emerged, of which 25 were derived from pupæ formed during the previous September–October, 35 from pupæ formed the preceding August and the remaining 27 from pupæ formed the previous May, June and July.

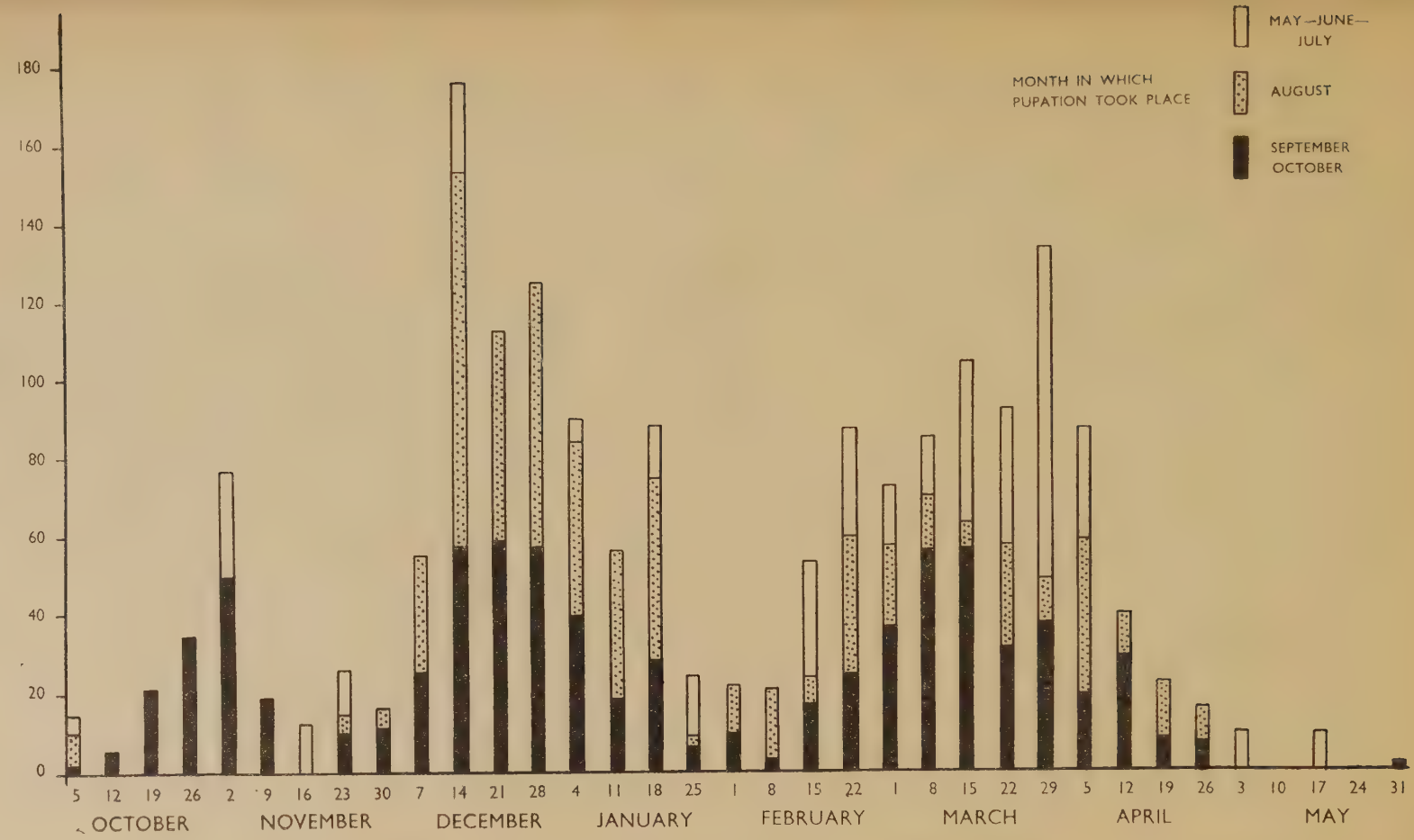


Fig. 5. Moth Production per Acre from Diapause Pupae, Chiromo, 1940-1941

The value of data of this sort in suggesting measures of control is obvious: clearly, with a diapause moth flight of this character, the later planting can be delayed the greater will be the proportion of the total diapause flight which the crop will evade. In 1941, with the bulk of the crop planted about 1 February and becoming attractive to egg-laying moths 4–5 weeks later, *i.e.*, during the first fortnight of March, only about one-third of the total diapause moth flight was late enough to oviposit on the crop. Had planting occurred in, say, early December, about two-thirds of the total flight would have laid eggs on the crop and the initial infestation would have been doubled. It is, of course, impossible to avoid some part of the diapause flight, because it goes on for so long. Indeed, at certain points this year there was evidence that at least part of the emergence (that from pupæ formed the previous late dry season) did not commence until April and reached its peak in May, whilst there were a few records of moths emerging after being over a year in diapause.

Looking at the data another way, had it been possible to exclude pupæ being produced the previous September–October, *i.e.*, had the close season extended from the end of August, roughly 40% of the whole diapause flight would have been eliminated.

It must be realised, however, that these methods of reducing the initial infestation are to a great extent mutually exclusive, since if cotton is planted late it will *usually* mature its crop after the cool weather, in August–September, and will thus be bound to give rise to a large population of diapause pupæ. If, on the other hand, cotton is planted early enough to make a pre-cool season crop and is then cut out in July, the August–October derived fraction of the diapause flight is eliminated, but the whole weight of the remainder is borne by the crop, with the probability that the May–July pupal contributions to this flight will be very greatly increased. It is, however, possible to calculate from the moth emergence data what effect the various possible manipulations of crop production would have on the effective seasonal carry-over of diapause pupæ, and hence their effectiveness as control measures—provided that the introduction of such measures would not alter the fundamental pattern of bollworm bionomics, as at present observed, in such a way as to defeat those measures.

Experimental work on the mechanism of pupation, as distinct from observational work on the actual course of pupation, is necessary to test this proviso. This is the *raison d'être* of the experimental work described elsewhere in these Reports.

The moth flight data given here are subject to one important qualification. Being based on the emergence of moths from larvæ

allowed to pupate in the absence of predators, the emergence figures are all rather higher than under natural conditions ; seasonal variation in the predator attack will also cause some distortion of the emergence curve. In order to obtain information on this point and on the mortality due to all causes in pre-pupal and pupal life, weekly samples of larvæ have been allowed to pupate under field conditions, exposed as freely as possible to predator and other influences, and the extent and cause of mortality determined. Samples of pupæ are also put out weekly, fully exposed to natural conditions (being merely buried in the soil, with their positions marked by metal labels) and examined every week to detect the date and cause of death. Duplicate samples are exhumed at very long intervals only, so that estimates may be made of the effects of the weekly examinations. The results will be discussed next year ; those to date give us confidence in the hitherto unrefined data from the pupation cages.

PROGRAMME OF WORK, 1941-42.

1. The observational work will be maintained, comprising records of insect populations and crop development and loss in sample gardens selected on the basis of a crop census, with all relevant climatic data.

2. The time-of-planting experiment will be repeated at Chiromo sub-Station and analysed by taggings and plant diagrams.

3. A variety trial and an experiment on the relation between time of planting of maize and inter-cropped cotton will also be carried out.

4. Pupation cage work will be continued in all districts.

5. Pupal mortality records will be continued (*a*) on the Cotton Station at Domira Bay and in a field cultivated in the native style ; (*b*) at Chiromo ; (*c*) in two other districts.

6. The effects of larval food on the length of pupal life will be studied. This will be carried out at constant temperature in an incubator in order to eliminate climatic factors.

7. The effects on the length of pupal life of subjecting pre-pupæ to different relative humidities will be worked out. This again will require the controlled temperature of an incubator.

8. The length of life of naked and cocooned pupæ will be compared under constant temperature conditions.

9. If, as seems likely, it becomes desirable to carry out experimental work on the effects of temperature on red bollworm pupation, this will be started wherever the most suitable facilities can be found.

10. Insectary work on stainer breeding will continue.

11. Recording work on wild host plants of stainers and their stainer populations will be started.

Included by courtesy of the Nigerian Government.]

NIGERIA.

PROGRESS REPORT ON WORK ON COTTON IN THE SOUTHERN PROVINCES FOR THE SEASON 1940-41.

Introduction.

Work on cotton continued to play a minor role in the plant-breeding programme of Southern Nigerian crops.

Meteorology.

Rainfall, during the critical period of growth, *i.e.*, July to October, was 25·26 inches, the previous three-year average for this period being 20·13 inches. The rain was well distributed and contributed to a good yield.

Genetics and Breeding.

Sixteen single plants were chosen from the selection plot of Ishan A in order to initiate the scheme of selection suggested by Mr. J. B. Hutchinson. Multiplication proceeded along the usual lines.

Entomology.

In order to limit attack by *Helopeltis*, which proved disastrous in the previous season, the selection and multiplication plots were isolated by protective belts of *Tephrosia candida*. *Helopeltis* attack was, however, practically negligible in the immediate neighbourhood, and therefore the efficacy of these protective belts could not be judged.

Summary and Conclusion.

In contrast to the previous four seasons the growth and yield of Ishan A in the selection and multiplication plots was very satisfactory.

PROGRAMME OF INVESTIGATIONAL WORK FOR THE SEASON 1941-42.

Maintenance of Ishan A.

1. Establishment of sixteen progeny rows (20 plants each). Selection of eight of these on row characteristics.
2. Protective belts of *Tephrosia candida* again to be tested.
3. Multiplication as in previous years.

Rough-linted Cottons.

Selections of rough-linted cottons have been made from native farms in Ishan Division of Benin Province (the original source of Ishan A). Progency rows of 100 such selections have been established.

No Report has been received this year on the work on cotton in the Northern Provinces.

WEST INDIES.

TRINIDAD COTTON RESEARCH STATION GENETICS DEPARTMENT.

PROGRESS REPORT FOR THE PERIOD OCTOBER, 1940—SEPTEMBER, 1941.

BY

J. B. HUTCHINSON, R. A. SILOW AND S. G. STEPHENS.

Introduction.

The season was a dry one, the rainfall during the wet season being below average, and the dry season severe and prolonged. Vegetative growth of cotton was less than usual, especially in the later plantings, and the crop ripened off rapidly. Some of the later plantings of Asiatic material were a failure. On the whole it was a good season however, as all types except Asiatics stand such drought as is experienced in Trinidad very well.

Pest incidence was moderate. A strict close season and a dry crop period kept down pink bollworm. It was very noticeable, however, that *G. barbadense* was more heavily attacked than *G. hirsutum*. It appears also that an attacked boll of *G. barbadense* is more severely damaged than one of *G. hirsutum*. *Sacadodes* was fairly common about January–February, but was never serious. Stainers were of no importance.

The season was too dry for blackarm and anthracnose to do much damage, but the most susceptible types were attacked. It is noteworthy that under humid Trinidad conditions hirsute and tomentose cottons of the New World group are almost always extremely susceptible to anthracnose. Some Asiatic types are also susceptible.

Genetic Research.

Developmental abnormalities.—The Nigerian rogue referred to last year has proved to be heterozygous in its original form. On selfing, it gives 1 normal : 2 Nigerian rogues : 1 extreme, sterile, corky. In crosses with Upland, it gave ratios near expectation on a three-factor basis, with normal dominant. Rogues tested from Upland F_2s have proved to be simple heterozygotes. The dominance relations of the factors concerned must be very curious.

Leaf shape.—The leaf shape locus in Asiatic cottons continues to provide material of great interest. Several further mutants have occurred in recent years in various lines carrying the laciniated gene, and the range of mutant material now available closely parallels the

field series in appearance. There may be as many as four new narrow mutant types, intermediate in expression between laciniated and broad. One at least of these narrow mutants behaves in the same way as the broad mutant L^B in relation to laciniated L^L, inducing mutation of the latter, in heterozygotes, to its own level, so that a plant which, from its origin, should be a laciniated-mutant compound, behaves in genetical tests as a homozygous mutant, *i.e.* $L^L\ L^B \rightarrow L^B\ L^B$; $L^L\ L^* \rightarrow L^*\ L^*$. From $L^B\ L^*$ compounds it is similarly not possible to recover the latter gene, showing that $L^B\ L^* \rightarrow L^B\ L^B$. Thus in certain combinations the new narrow appears to act upon its partner as a mutation-inducing agent, whilst in other cases it is itself induced to mutate. The stage in the ontogeny of the plant at which this effect occurs presents an intriguing problem. It is not known whether the change occurs at gametogenesis, or whether in fact the heterozygote exists at all somatically. An experiment has been devised to test this point.

Two simple leaf types have recently appeared in India, at Nagpur and Coimbatore respectively. It has been found that the same mutant is concerned in these two widely-separated occurrences, which happened to appear at much the same time. The locus is independent of the leaf shape multiple allelomorph series.

Studies of leaf shape development in New World cottons suggest that the situation is simpler than in Asiatic cottons. It seems fairly clear that the production of a three-lobed leaf may be attributed to differential growth rates along the main veins and in the tissues lying between them. Differences between three-lobed leaf types may be interpreted as a simple gene control superimposed upon the developmental plan of the Normal leaf, and initiated at progressively earlier stages of development in the Sea Island, Okra, and Superokra leaf types respectively. The leaf shape multiple allelomorph series therefore fits into a similar scheme to that of the eye colour in *Drosophila*.

Anthocyanin inheritance.—A re-investigation of anthocyanin inheritance in Asiatic cottons, undertaken in collaboration with Mr. C. P. Yu of the Agricultural College, National Central University, Chungking, China, has been brought to a close and a paper on the subject submitted for publication in the *Journal of Genetics*. The anthocyanin allelomorph series has been extended to fourteen members by the acquisition of six new types from Chinese field material, and a seventh which occurred as an anomaly in experimental cultures. The latter and other similar anomalies which have occurred in our material have received considerable attention on account of their theoretical importance in the interpretation of characters with manifold

expressions, particular arrangements of which behave as strictly alternative units in inheritance, and which are usually referred to multiple allelomorphs. Although new "pattern" arrangements appeared in our experiments under controlled conditions, and might therefore have been expected to be particularly suitable subjects for investigation, it was not found possible, on their basis, to reach any decision between the alternative interpretations of close linkage and multiple allelomorphism with pleiotropy.

Anthocyanin inheritance in the New World diploid and tetraploid species is also under investigation, especially with a view to distinguishing between mutation and modifier effects in inter-species crosses. This experiment is still in progress. A close linkage between the duplicate *anomalum* anthocyanin locus and a new corolla colour factor found in Chinese material has been observed.

Lint colour.—The existence of two main lint colour factors has been demonstrated in Upland. One is a brown of moderate intensity, giving a 1 : 2 : 1 ratio in F_2. It resembles in appearance and behaviour the brown lint of wild relatives of Upland, and is probably genetically identical with it. Modifying factors frequently obscure the simple segregation. The other is an intense mahogany red colour, not uncommon in Peruvian *G. barbadense*, but only known in one Upland strain from Colombia. It is likely that it has been derived from *G. barbadense* by hybridisation. Dominance is nearly complete, and segregation into mahogany and white or light brown is always clear. The main interest of mahogany is that it results in a considerable reduction in lint length and in lint maturity. The immaturity of mahogany samples is so marked that mahoganies and whites can be separated quite easily by feel alone.

Mahogany behaves similarly in *G. barbadense*. The light browns in *G. barbadense*, however, are difficult to classify. Modifier segregation is considerable, and simple segregation does not usually occur. A partial transference of Upland brown to Sea Island suggests that white-linted *G. barbadense* is usually a light brown with a very low modifier content while Upland white is a true white with a fairly high modifier content.

Inheritance of "Corky."—It appears that "corky" is due to complementary genes, one of which occurs in West Indian Bourbons and the other in Sea Islands. Since the experiment began, other corky types have been found (1) a recessive type in *G. barbadense*×*G. thurberi* crosses and probably distinct from the Bourbon/Sea Island corky, (2) a type whose inheritance is still being investigated in backcrosses of *G. raimondii* to *G. barbadense*. The situation was more

complex than was thought at first, as Bourbons which give corky hybrids with Sea Island types do not necessarily give cork with certain Egyptian types. It seems probable that there are "cork carrying" and "non-cork carrying" types in *G. barbadense* as well as in *G. purpurascens*. Work in this experiment proceeds slowly since close season requirements restrict the flowering season of the photoperiodic Bourbon types.

Inheritance of fuzz.—The early stages of the work have shown considerable differences in modifier background even within the *hirsutum* species. In one case the F_2 of two semi-lintless, naked seeded Upland varieties gave a complete range from fuzzy fully linted to naked completely lintless seeded types. Under such circumstances it was considered useless to carry out transferences from general *hirsutum* to general *barbadense* backgrounds or *vice versa*, and definite *barbadense* varieties have been chosen as standard backgrounds to which the various fuzzy, tufted and naked types in *hirsutum* and *barbadense* can be transferred. *Barbadense* types are chosen as standard backgrounds in preference to *hirsutum* as main fuzzy gene segregation is on the whole clearer in the former species. The preliminary work has shown that the naked gene is strongly associated with a reduced lint cover of the seed, which in turn is associated, though less obviously, with reduced lint index. It remains to be discovered whether the lint indices of tufted seeds are lower than those of fuzzy seeds.

Genetics of lint density.—Analysis of the results obtained last season on the dominance and interaction of the minor quantitative genes affecting lint density in Asiatic cottons has revealed a very unexpected effect. On the interaction hypothesis it had been expected that the effect of the minor genes would be at a minimum in the highest part of the range of expression of the major gene concerned—its duplex phase. In the relatively few plants of the latter genotype which occurred in the families investigated no significant effect of the minor gene on lint percentage could be observed, but there was surprisingly a significant effect on seed size, which is unaffected in the nulliplex phase of the main gene, where the only apparent effect of the minor gene is on number of lint hairs. Such a diversion of gene function at different levels of expression, being of considerable significance to genetical theory, requires confirmation, and warrants the retention of this investigation as a major problem for a further period.

There have been indications that the diploid species are themselves derived polyploids, and, whenever possible, attempts are made to substantiate this genetically. One method available is by the detection of chromosome homologies within a particular species genom. The

Dharwar glabrous lintless in *arboreum* (h_a) has been found to be closely linked with one of the three known lint colour loci. The recently acquired duplicate Punjab glabrous lintless (h_b) was therefore tested against the other two lint colour loci. Independent inheritance has been observed in both cases. It has also been found that the Punjab glabrous lintless is quite unaffected by the minor genes which modify the expression of Dharwar glabrous lintless. Thus there is no evidence that the two lintless genes indicate any chromosome homology, and it is probable that they attain their expression in totally different ways. It is known that the Dhawar mutant controls the density of lint hairs on the seed; it is hoped, from an investigation of dominance relationships which is being undertaken, to obtain information on the mechanism concerned in the Punjab type.

Cytology and the effect of colchicine.—A study of the cytology and fertility relations of the colchicine-produced tetraploid Asiatic cotton has now been completed and will be published shortly. A cytological study of some triploid hybrids, derived by crossing tetraploid Asiatic ♀ × wild diploid species ♂, which throws further light on the homologies existing among diploid cottons, is also approaching completion. The cytological behaviour of the tetraploid suggests that polyploids with greater somatic chromosome numbers than 52 are not likely to be fully fertile. It is believed that any practical application of colchicine treatment to breeding work will be in the synthesizing of new amphidiploids cytologically homologous with present day New World cottons, thus enabling Asiatic and wild diploid characters to be transferred to the New World genotype.

A highly sterile rogue found by Evelyn in V.135 multiplication stocks has been under study for some years. Intermediates were obtained in crossing with normal, and these on selfing give regularly about 56 per cent. normals; 41 per cent. intermediates; 3 per cent. sterile rogues.

Both intermediates and rogues show rings in a proportion of their meiotic 1st metaphase plates which suggests either autosyndetic pairing or translocations leading to association of non-homologous chromosomes. Both also show a large proportion of pollen mother cells containing half or approximately half the expected number of chromosomes. It is obvious that they are cytologically aberrant, and that further genetic studies must await a cytological analysis which is now in progress. One interesting point is that although intermediates and rogues are readily distinguishable in the field yet cytologically no difference has so far been found between them.

Quantitative inheritance.—F_2s, backcrosses and F_3s of two

intra-species hybrids were grown. Unfortunately, the value of the data collected was very much reduced by the discovery that the amount of seed cotton per boll is considerably less in selfed than in open pollinated bolls. No previous record of such a reduction is known, but it has been suspected for some time that fertilisation was hindered by tying up the flowers of types with very long stigmas. The reduction in seed cotton per boll probably results from the setting of fewer seeds per boll. Plant breeders who normally self their material will be well advised to compare the weight of seed cotton and number of seeds obtained from selfed and unselfed bolls.

In the inter-Upland cross attention is concentrated on the relative importance of the components of yield. In the short season experienced the small-bolled U.4 parent and segregates resembling it failed to compete with the large-bolled Triumph type because the whole crop dried up before the prolific setting of the U.4 type was realised.

There must be a level at which plant yield is determined by more fundamental physiological relationships than boll number and boll size, and at that level there will be a negative correlation between boll number and boll size, such that their product falls off according to the law of diminishing returns. Since there was no correlation between them in this material, the yield level was presumably below the level at which other factors become limiting.

The parents of the *G. barbadense* cross were V.135 Sea Island and a Colombian long period, big-bolled strain. In F_2 and F_3 a new simple leaf type appeared as a double recessive. This suggests a considerable difference between them in genetic make-up, which is interesting in view of the possibility that the Sea Island group may have been derived from Colombian types of *G. barbadense* introduced into the United States by way of Cuba and the Bahamas.

In view of the frequent references in Reports from Experiment Stations to the need for timing the crop to avoid pest attack, this material is being used for the experimental development of a Sea Island variety with a crop cycle two months longer than that of the varieties now cultivated. Such a long cycle variety could be sown on the early rains and still fruit in the dry weather.

Work on the Sea Island Crop.—A study of the variation of spinning value and hair characters due to environmental influences has been completed. The most important consequence of environmental variation is variation in immaturity. In general, brokers' valuations of immature samples run about 2d. per lb. (or 10 per cent.) lower than those of well matured samples. Spinning value does not appear to be affected, so the lower value of immature cotton must be due to a

lowering of other quality characteristics. The actual environmental factors affecting immaturity have not yet been discovered.

Type collection.—A number of semi-sterile rogues have been obtained from multiplication areas and main crop fields of St. Vincent and Montserrat Sea Island, and also a very interesting mutant from Montserrat with non-expansive lint. Non-expansive lint is otherwise only known from wild 13-chromosome cottons.

Extremely hairy Upland types from the Philippines and the intensely tomentose *G. mustelinum* may be of value in breeding for jassid resistance, and the types or their hybrids with U.4 have been sent to Barberton for test.

PUBLICATIONS.

Silow, R. A. 1941. "The comparative genetics of *Gossypium anomalum* and the cultivated Asiatic cottons. *J. Genet.* **42**, 259–358."

Silow, R. A 1941. "Dominance an incidental manifestation of general gene interaction." *Chron. Bot.* **6**, 174.

SUMMARY & PROGRAMME.

It will be seen that the work of the year has followed closely the lines of the programme laid down in the 1938–9 Report. Genetics programmes change slowly, and there is little to add at present.

Though the programme is on the face of it almost entirely academic, an increasing proportion of our time is being devoted to the study of problems of practical importance. The classification of the type collection has improved our knowledge of material of value to plant breeders and this, together with the information collected by Silow during his visit to the American cotton belt in 1939, have resulted in more frequent seed exchanges and more comprehensive advice to breeders interested in introducing material for specific purposes.

Species differences having been settled, sub-specific groupings are receiving attention from a number of angles. The distribution of genes controlling corky and *barbadense* simple leaf, and modifiers of the dominance of crinkled and its alleles, promise valuable information on genetic groupings in *G. barbadense*. Manning's work on the relationships of the Sea Island group of cottons is referred to in the Report from the St. Vincent station.

Quantitative inheritance studies, which constitute the direct attack on plant breeding problems, still proceed slowly, as they are long-period experiments. Meanwhile, analyses of the records of Sea Island breeding work are in progress, and are giving valuable support to the breeding principles developed at Indore and in Trinidad and St. Vincent. The collection and genetic analysis of rogues from the St. Vincent and

Montserrat Sea Island breeding stocks has shown the importance of a careful genetic scrutiny of all material that is being multiplied rapidly. Since rapid multiplication usually involves a reduced seed rate, and consequently less seedling competition, deleterious mutants have a better chance of survival in multiplication stocks than in ordinary field crops.

The induction of polyploidy by colchicine treatment was undertaken to discover what value, if any, the method might have for the production of new types of cotton of agricultural value. It has been carried to the point where a general review of the possibilities of induced polyploidy in cotton is being prepared, which it is hoped will serve as a guide to all who contemplate working on the subject.

The importance of immaturity in determining the value of cotton lint has been shown up by the study of the hair characters, spinning values, and brokers' valuations of samples of Sea Island cotton. Recently it has been shown (Moore, 1941, *J. Agric. Res.* **62,** 255) that the distribution of lint hairs on the seed has a marked effect on the immaturity of the lint. The study of fuzz and lint distribution now in progress should throw further light on this factor, as well as on the importance of seed coat cover in determining ginning outturn. Genetic control of immaturity is also under investigation, since it has been found that the mahogany lint colour gene is responsible for a considerable reduction in maturity.

Our closest contact with practical breeding is, of course, with the Sea Island work in St. Vincent and Montserrat, but in spite of the delays and uncertainties of the mails, discussion of the problems of applied genetics with cotton breeders in other parts of the Empire still continues.

PHYSIOLOGICAL DEPARTMENT

OUTLINE REPORT ON WORK DONE DURING 1941.

BY

T. G. MASON and E. PHILLIS.

Work has been chiefly concerned with mineral nutrition and hydration. The disc-cutting technique mentioned in last year's report has been extensively used in these investigations.

Mineral Nutrition.

The primary object of our studies on mineral nutrition is the development of rapid methods of diagnosing the mineral status of the cotton plant. So far, we have found that the presence of appreciable quantities of starch in the leaf at dawn is usually associated with mineral deficiency. Turning to individual elements, we have found that the proportion of the total N present in the leaf in the crystalloid form increases as the nitrogen supply to the leaf is increased. We have extended the range of our investigations to cover both known nitrogen deficiency and nitrogen excess and have found that as the supply is increased from deficiency to excess, protein per 100 gm. dry matter increased up to a maximum value and then declined.

We have explored the factors governing the relation between crystalloid and protein-N. It is currently believed that the equilibrium is controlled from outside the leaf, possibly by hormones originating in the root. Our disc culture technique has enabled us to show that this view is quite unfounded, for discs are just as capable of forming protein as leaves on the plant.

The equilibrium between crystalloid and protein-N appears to be determined almost entirely by the concentration of crystalloid-N; the only additional factor we have so far found being age of leaf, and this has only a slight effect. Wide changes in mineral nutrition and in environment do not seem to have any effect on the relation whatsoever. The relation between the concentration of crystalloid and protein-N suggests that the equilibrium between the two is governed by an adsorption factor. The data available for the relations between soluble and insoluble phosphorus and for soluble and insoluble carbohydrate suggest that these equilibria are also governed by a similar adsorption factor. A paper incorporating these results has been prepared and will, we hope, be published shortly.

Potassium does not behave like nitrogen and phosphorus in its distribution between soluble and insoluble phases, for its partition is largely controlled by other bases. We have found that the potassium

status of a plant can be determined by the effects of partial defoliation. Leaves of plants low in potassium show a high sugar content which is greatly reduced on pruning, whereas when potassium is plentiful, pruning tends to increase the sugar concentration. Another possible method of potassium diagnosis lies in the determination of the vertical gradients in potassium per 100 gm. dry weight in the leaf which are positive while potassium is limiting growth and negative at higher supplies.

Hydration.

In last year's report we noted that leaf hydration was increased by potassium starvation under a normal day, while the reverse obtained under a short day. In the literature there are cases recorded in which potassium starvation has increased leaf hydration and other cases where it has decreased it. Experiments on this matter have led us to conclude that the basic effect of increased potassium supply is to increase hydration, but that where an increase in the size of plant results from the increased potassium supply, this may in turn lead to water strain, causing a reduction in hydration. In general, pot experiments show a negative correlation between potassium supply and hydration, while field experiments show a positive one. Even in pot experiments, the positive correlation can be obtained provided care is taken to avoid differences in water strain, as for instance, by growing plants with 6 hours exposure instead of the normal 13 hours.

Our experiments on the changes in hydration induced in discs by floating them on dilute salt solutions have been continued. An increase in the osmotic pressure of the cell sap does not appear to be the cause of water uptake by discs, for we have observed cases where osmotic pressure has risen and water content fallen and *vice versa*. The indications at present are that *total salt content* may be the controlling factor. If the analogy between the salt swelling of protoplasm and the swelling of gelatin holds, it may be that the salt concentration in terms of protein in the cell may be an important factor controlling hydration.

However this may be, it seems certain that the orthodox osmotic view of cell water regulation is incapable of explaining these disc phenomena. This work on the relation between salt content and water content in discs has been extended to intact leaves on the plant. The results to date corroborate the conclusions arrived at with the discs, viz., that the water content is largely determined by the salt concentration per 100 gm. protein.

Molisch has suggested that leaf senescence may be due to the continued accumulation in time of salt in the leaf and recent Russian

work suggests that high protein may protect leaves against salt injury. Dastur, in the Punjab, has also found that cotton plants can be protected from " tirak " by fertilising with ammonium sulphate. Our present view is that salt causes increased hydration of protoplasm (possibly due to its protein content) and that as the salt content increases, the gel properties of protoplasm (*i.e.*, its structure) are destroyed as a result of peptisation.

WEST INDIES.

COTTON EXPERIMENT STATION, ST. VINCENT.

INTRODUCTORY NOTE

BY

J. B. HUTCHINSON.

The cotton breeding work at the Cotton Experiment Station, St. Vincent, has two objectives. The first is to provide, and maintain at the highest possible level of purity, a supply of seed of superfine Sea Island cotton large enough to plant the whole of the island's cotton acreage. The second is to explore the breeding possibilities of the Sea Island group of cottons, with the object of providing better varieties for the West Indian islands, and gaining information of wider interest on the scope and limitations of cotton breeding.

The first part of the programme was rapidly reduced to a routine. During the past ten years no seed has been released for planting that was more than three generations from self-fertilised progeny rows.

The second objective was added in 1937, when experiments unrelated to the needs of the Sea Island industry were transferred to Trinidad. Progress has been rapid, and papers now in course of preparation will discuss the history and relationships of the varieties of Sea Island cotton now available, and the breeding history and present status of St. Vincent superfine. It is sufficient here to say that there are three distinct types of West Indian Sea Island : the superfines, the St. Vincent ordinaries, and MSI. There is considerable variation in the first two groups, but there is little doubt that the greatest scope for future breeding work lies in hybrids between members of the superfine group and MSI.

The St. Vincent type collection includes all Sea Island varieties it has been possible to discover from the literature or by correspondence. West Indian varieties have been compared in a number of variety trials and their comparative behaviour in St. Vincent is now fairly well understood. Only one variety (BD) besides those now in cultivation is ever likely to be of agricultural importance. Introduced varieties still remain to be tested. The chief value of the type collection is as a reservoir of breeding material, and the records now being collected of the characters of the varieties in yield trials will serve as a basis for new breeding work.

Manning has studied the effect of fertility level on the relative importance of boll size and number of bolls in determining yield, and concludes that whereas at the highest fertility levels the variety with

the greatest number of bolls excels, at low fertility levels the variety with the largest bolls gives the highest yield. Superfine varieties, including V.135, produce a large number of small bolls, whereas MSI has large bolls, but does not carry so many of them. Since the yield per acre on the peasant lands, which comprise over half the cotton acreage, is less than half that on estates, breeding a large-bolled superfine cotton for poor lands would result in a very substantial improvement in the island's crop.

Recent main breeding trials have shown that the variance in V.135 material is so low that there is no hope of any appreciable response to further selection. The VH hybrid material (V.135 × MSI), however, offers the possibility of combining the yield characteristics of MSI with the superfine quality of V.135, and selection to this end has been in progress for three seasons. In the experiments under report, VH material was tested extensively and in the small bulk trial it will be seen that only the two main V.135 strains (V(30)46 and V(37)11) were included, as controls. The excellence of the VH material is well demonstrated. The current report marks a stage in the history of the breeding work, in that in the forthcoming season V.135 will be grown for seed supply only, and not for selection, and the whole of the selection work will be exercised on VH material with the definite object of breeding a large-bolled, high lint index, superfine variety that will give a better return on poor land.

In view, however, of the importance of maintaining the supply of V.135 at the present time, the authorities will not be advised to put any of the VH selections into commercial cultivation during the war or without previous consultation with the Colonial Office and the consumers.

PROGRESS REPORT FOR THE SEASON 1940-41 AND PROGRAMME OF EXPERIMENTS FOR THE SEASON 1941-42

BY

H. L. MANNING.

1. Introduction.

Climatic conditions were quite favourable at the Experiment Station and, but for the now commonly recurrent attacks of pink bollworm, the season can be said to have been quite successful. The island generally suffered from the dry spell in January so that the crop was rather lower than was first expected.

The total area under cotton amounted to 5,180 acres, of which 2,834 acres were peasant cultivation. The island yield of 582,955 lb. of white lint thus gave an average yield of 112½ lb. per acre.

The island's planting seed supply area of 95 acres produced 21,246 lb. of lint. It is estimated that 50,000 lb. of pedigree seed will be available for planting next season.

2. Genetics and Breeding.

The Main Breeding Trial.

Introduction.—The now familiar technique of Hutchinson and Panse, with ten replications of twenty strains in five-plant plots, was carried out.

The material used consisted of three main variety groups, which included ten selected V.135 progenies, six V.135 × Montserrat hybrids (VH) and four Barbados Sea Island progenies.

In the list which follows the ancestry of the 1940 progenies is given.

Material.

Variety.	*Strain.*	*Family.*	*Selected for*	*No. of Plants Selected.*	1940 *Progenies.*
V.135	V(30)46	V(39)10 ...	Lint Length and Bolling ...	2	V(40)8 & V(40)9
	V(37)11	V(39)8 ...	Lint Length and Lint Index ...	2	V(40)6 & V(40)7
		V(39)11 ...	Ginning %	1	V(40)10
		V(39)16 ...	Total Lint and Lint Index ...	2	V(40)13 & V(40)14
	S.2	V(39)4 ...	Seed Weight	2	V(40)3 & V(40)4
		V(39)3 ...	Bolling	1	V(40)2
VH	VH.8 ...	VH(39)2 ...	Total Lint, Bolling and Good Parental Spinning Test.	1	VH(40)1
	VH.9	VH(39)5 ...	Lint per Boll, Lint Index and Ginning %.	1	VH(40)5
		VH(39)12	Lint Length	2	VH(40)11 & VH(40)12
	VH.10 ...	VH(39)17	Bolling and Total Lint... ...	2	VH(40)15 & VH(40)16
B.S.I.	P.170–2	B(39)1 ...	Lint Length	2	B(40)17 & B(40)18
		B(39)2 ...	Seed Weight, Lint Index and Ginning %.	1	B(40)19
		P.170–2–17	Ginning %	1	B(40)20

Analytical Results.—Examination of the summary below (Table I) shows that the varieties had characteristically different mean values for days to first flower, boll loculi value, bolling, lint per plant, lint per boll, seeds per boll, lint index and lint length.

Table I is preceded by the tabulated mean values of the Main Strains, the significant differences between which are indicated.

Flowering	VH 69·4	BSI 69·7	V.135 70·9
Boll Loculi	VH 3·342	BSI 3·154	V.135 3·028
Bolling	BSI 33·5	V.135 28·6	VH 26·6
Lint per Plant	VH 18·7	BSI 18·3	V.135 17·0
Lint per Boll	VH 0·70	V.135 0·60	BSI 0·55
Seeds per Boll	V.135 14·7	VH 13·7	BSI 13·4
Lint Index	VH 5·11	BSI 4·09	V.135 4·07
Lint Length	V.135 61·2	VH 60·5	BSI 59·3

TABLE I.

Variety.	*Strain.*	*Progeny.*	*Days to Flower.*	*Boll Loculi Value.*	*Bolls per Plant.*	*Lint per Plant.*	*Lint per Boll.*	*Seeds per Boll.*	*Lint Index per Seed.*	*Lint Length.*
						Gms.	*Gms.*		*mg.*	*mm.*
V.135	V(30)46	V(40)8	67·7	3·015	31·9	18·6	0·59	14·8	3·96	61·5
		V(40)9	70·7	3·025	28·7	16·2	0·57	14·4	3·94	61·5
	V(37)11	V(40) 6	69·0	3·028	29·7	17·7	0·59	14·5	4·10	61·1
		V(40) 7	71·0	3·045	27·8	16·4	0·59	14·1	4·21	61·2
		V(40)10	71·6	3·029	26·1	16·4	0·63	15·0	4·20	61·2
		V(40)13	72·2	3·030	29·2	17·3	0·60	14·6	4·12	61·1
		V(40)14	72·3	3·040	28·5	17·9	0·62	14·7	4·24	60·9
	S.2	V(40) 2	71·4	3·026	27·5	16·3	0·59	14·7	4·01	61·0
		V(40) 3	73·0	3·022	26·8	15·6	0·57	15·1	3·84	61·4
		V(40) 4	70·3	3·024	30·1	17·5	0·60	14·8	4·06	61·3
MEAN	...	...	70·9	3·028	28·6	17·0	0·60	14·7	4·07	61·2
VH	VH(38)8	VH(40) 1	68·4	3·281	31·1	20·6	0·66	13·7	4·83	60·8
	VH(38)9	VH(40) 5	69·4	3·340	25·6	18·4	0·71	14·1	5·03	60·9
		VH(40)11	69·6	3·332	27·9	20·0	0·72	13·8	5·21	60·8
		VH(40)12	67·8	3·380	24·8	17·5	0·71	13·6	5·20	60·8
	VH(38)10	VH(40)15	71·2	3·356	24·2	17·1	0·71	13·7	5·14	59·8
		VH(40)16	70·0	3·363	26·1	18·4	0·70	13·4	5·24	60·1
MEAN	...	...	69·4	3·342	26·6	18·7	0·70	13·7	5·11	60·5
BSL	P.170–2	B(40)17	68·3	3·146	31·2	17·3	0·55	13·2	4·17	59·8
		B(40)18	72·0	3·162	31·9	17·2	0·53	13·0	4·08	59·0
		B(40)19	68·2	3·178	40·4	22·2	0·55	13·7	4·06	59·2
		B(40)20	70·1	3·131	30·5	16·6	0·55	13·7	4·03	59·2
MEAN	...	...	69·7	3·154	33·5	18·3	0·55	13·4	4·09	59·3
C.V.%	...	...	6·7	1·3	21·3	22·7	6·0	5·5	3·2	1·0

Small Bulks Trial.

This trial, by which the results of the Main Breeding Trial of the previous season are checked, consisted of eight VH hybrids from the three VH strains, and one V.135 from each of the strains V(30)46 and V(37)11. While the plot size was comparatively small (1/160 acre) it will be seen that the precision was high enough for good yield comparisons.

Strain.	1939–40 *Parents.*	1940–41 *Bulks.*
VH(38) 8 ...	VH(39)2 and VH(39)7	VB1 and VB3
VH(38) 9 ...	VH(39)5, VH(39)12, VH(39)13 and VH(39)19 ...	VB2, VB6, VB7 and VB10
VH(38)10 ...	VH(39)15 and VH(39)17	VB8 and VB9
V(30)46	V(39)10	VB5
V(37)11	V(39)8	VB4

Correlations between bulked parent strains of 1939–40 and their respective progeny in this trial of 1940–41 indicate substantial agreement.

Lint Index = +0·96 ... ... p = Very small.
Ginning % = +0·97 ... ... p = Very small.
Lint Length = +0·76 ... . p = 0·01.

These high values are partly due to large differences between V.135 and VH. When the variety differences have been eliminated, however, the within-variety correlations are still of the order of +0·70 for lint index and ginning percentage.

Data for morphological and seed cotton characters are summarised in Table II (page 205). The degrees of freedom were partitioned into those due to strains and those within strains. Significant differences between strains were recorded for all characters. There were also some small but significant differences within strains for ginning percentage, seed weight, lint index and lint length.

This trial is the first occasion on which the high lint index strain, V(37)11, has outyielded, though not significantly, the high bolling strain V(30)46.

Discussion of Breeding Results.

In the analysis of variance of the Main Breeding Trial allocation of the total degrees of freedom due to varieties has provided useful variety comparisons. Significant differences were recorded for all morphological and seed cotton characters except germination, number of monopodial branches and seed cotton per plant.

The increments in boll weight and associated values for the VH progenies, over V.135 and BSI, are clearly demonstrated. In lint length these hybrids have all attained a satisfactory standard and their future is largely dependent on the results of the small-scale spinning tests.

The BSI progenies were, as expected, significantly better "bollers" than either the V.135 or VH, though results recorded for other characters were disappointing. It is interesting to note that the great advantage gained in bolling compensated for the poor boll weight figures in so far as total lint per plant was concerned.

Within the varieties V.135, VH and BSI further partition of the degrees of freedom has been carried out where significant differences were recorded.

TABLE II.

Strain.	*Germination.*	*Flrs. at 69 Days.*	*Total Seed Cotton.*	*Total Lint.*	*Lint Index per Seed.*	*Ginning %*	*Seed Weight per Seed.*	*Lint Length.*
			Kgm.	*Kgm.*	*mgm.*		*mgm.*	*mm.*
(A) V(30)46								
VB5=4(39)10 ...	103·7	18·4	2·347	0·588	4·00	25·0	12·02	61·7
(B) V(37)11								
VB4=4(39)8 ...	106·8	22·8	2·377	0·628	4·36	26·3	12·20	61·1
(C) VH.8								
VB1=VH(39)2	108·2	20·0	2·398	0·718	5·09	30·0	11·91	60·6
VB3=VH(39)7	113·6	17·8	2·373	0·738	5·52	31·1	12·22	60·8
Mean... ...	110·9	18·9	2·386	0·728	5·30	30·5	12·06	60·7
(D) VH.9								
VB 2=VH(39) 5	116·8	25·0	2·228	0·672	5·55	30·1	12·90	60·3
VB 6=VH(39)12	114·7	24·7	2·148	0·651	5·60	30·3	12·87	61·6
VB 7=VH(39)13	109·6	20·3	2·135	0·647	5·44	30·3	12·53	60·6
VB10=VH(39)19	116·9	22·6	2·138	0·646	5·47	30·2	12·65	58·9
Mean... ...	114·5	23·2	2·162	0·654	5·52	30·2	12·74	60·3
(E) VH.10								
VB8=VH(39)15	115·8	25·6	2·134	0·647	5·49	30·3	12·66	59·0
VB9=VH(39)17	119·8	26·1	2·127	0·648	5·52	30·5	12·62	59·2
Mean... ...	117·8	25·9	2·131	0·647	5·51	30·4	12·64	59·1
General Mean	112·6	22·3	2·241	0·658	5·20	29·4	12·46	60·4
C.V. %	11·0	29·3	15·0	15·0	2·6	1·7	1·5	1·2
F for Strains ...	8·82	9·33	10·39	12·48	1479·92	1377·69	247·0	46·35
Significance of Differences ...	**	**	**	***	V.S.	V.S.	V.S.	***

Throughout this Report * indicates $0·05 > P > 0·01$; ** $0·01 > P > 0·001$; *** $P < 0·001$ VS., P very small indeed.

STRAIN ORDER AND SIGNIFICANCE OF DIFFERENCES.

Germination	VH.10, VH.9, VH.8, V(37)11, V(30)46
Flowers at 69 Days	VH.10, VH.9, V(37)11, VH.8, V(30)46
Total Seed Cotton	VH.8, V(37)11, V(30)46, VH.9, VH.10
Total Lint	VH.8, VH.9, VH.10, V(37)11, V(30)46
Lint Index per Seed	VH.9, VH.10, VH.8, V(37)11, V(30)46
Ginning %	VH.8, VH.10, VH.9, V(37)11, V(30)46
Seed Weight per Seed	VH.9, VH.10, V(37)11, VH.8, V(30)46
Lint Length	V(30)46, V(37)11, VH.8, VH.9, VH.10

Throughout this Report strains not differing significantly are bracketed together.

V.135 includes three strains, (1) descendants from V(30)46—the original 1930 selection; (2) those from V(37)11—the high lint index selection of 1936; and (3) some commercial re-selections designated S.2. Examination of results indicates clearly the effect of selection during the past four seasons. The V(37)11 descendants have significantly better lint indices and ginning percentages, for which strong selection pressure has been exercised, than the V(30)46 and S.2 progenies.

Lint Index (gms.)	V(37)11= 4·24	S.2= 4·07	V(30)46= 3·95
Ginning Percentage	V(37)11=24·70	S.2=24·03	V(30)46=23·44

In this experiment the advantage of V(37)11 in lint index is counterbalanced by the rather better bolling of V(30)46 so that there was no difference in lint per plant. In the Small Bulks Trial, however, this advantage in lint index was reflected as a 6% advantage in lint yield. In 1939–40, V(30)46 yielded very slightly more than V(37)11 in both these trials—in spite of the advantage of the latter in lint index. Clearly then, the strong and successful selection pressure exercised in favour of lint index in V(37)11 has not resulted in any appreciable increase in lint yield, and it is suggested that in V.135 material a physiological balance has been reached, such that any increase in any component of yield is nullified by a corresponding decrease in another. Since Harland's analysis of yield in cotton, breeding work on Sea Island has been concentrated on those yield components (chiefly boll weight characters) with a low environmental variance in which, in consequence, genetic differences were easily detected in progeny row material. It was to be expected that progress on these lines would cease when such a physiological balance between boll number and boll size was reached, and it is now necessary to attack the problem of selection in characters, such as bolling, with a high environmental variance. This environmental variance may be reduced by increasing the plot size or by reducing the fertility variation in the experimental area. Preliminary studies on optimum plot size and manuring are reported below.

Selections were made on bolling, seeds per boll and lint per seed, as being the main yield components, with lint length as an additional factor—since this last is probably the most influential single laboratory determination affecting quality. With these characters in view the progenies from which the most useful material can be obtained are V(40)6 and V(40)14 of the high lint index series and V(40)8 of the high bolling series.

VH has again demonstrated its superiority over V.135 as regards yield. The three main strains are VH(38)8, which is high bolling, long linted and previously gave good spinning test results;

VH(38)9, in which there is a desirable combination of V.135 and MSI characters ; and VH(38)10, characterised by high bolling weight and the somewhat lower bolling of the Montserrat parent. Of particular interest is the evidence of transgressive inheritance, in these hybrids, for such characters as plant height, earliness and boll loculi value. Six sub-strains have been established, some of which are earlier, others taller, and others with a higher boll loculi value than either parent.

Progenies from which selections are to be made are VH(40)1, VH(40)5, VH(40)11 and VH(40)16.

The BSI strains, while providing a single progeny of undoubted high yielding capacity, have shown themselves to be far from pure for superfine lint length. In this important character they are below the standard of uniformity required for the St. Vincent seed supply. While they are being purified their physiological yield balance is worth studying, since they combine the highest bolling of all superfine strains with the lowest boll weight characters.

Next season's material will consist of selections from the two progenies B(40)17 and B(40)19.

Yield comparisons between V.135 and VH are summarised below.

Main Breeding Trial, 1939–40	VH.8	VH.10	VH.9	V.135
Main Breeding Trial, 1940–41	VH.8	VH.9	VH.10	V.135
Small Bulks Trial, 1940–41	VH.8	VH.9	VH.10	V.135
Variety Trial, 1939–40	VH.9		V.135	
Variety Trial, 1940–41	VH.9	V.135	VH.10	
Yield Test, 1939–40	VH.9	VH.8	VH.10	V.135
Yield Test, 1940–41	VH.10	VH.9	V.135	

It will be seen that there is good evidence that the VH material is higher yielding than V.135. Since VH is more variable and, therefore, more susceptible to improvement by selection, better yielding, and approaching superfine quality, it has been decided to concentrate the breeding effort on it, while maintaining sufficient progeny material of V.135 for seed supply purposes. As significant differences in plot variance have been detected between V.135 and VH in certain characters, they will in future be grown in separate experiments. Any further direct comparisons that are necessary will be made in the Small Bulks and Variety Trials.

The chief weakness of the current randomized complete block design of progeny row trials is that the number of progenies which can be tested is strictly limited. It is only possible to exploit hybrid material of high variability adequately by testing a large number of progenies. In the past more than ten VH progenies have never been grown in one season. In the coming season it is proposed to include thirty-one

progenies in a balanced incomplete block design, so as to give better sampling of the material as a whole, and a wide range for selection on quality, on the basis of small-scale spinning tests. A further advantage to be gained from this lay-out is that the reduction in block size (six plots) and the resulting increase in number of blocks is expected to reduce the error variance considerably.

The Experiment Station lands are in a fairly flat valley bottom and are maintained in a high state of fertility. The Variety Trial, which was grown on the poorest of the Station plots, averaged about 320 lb. of lint per acre as against the island means of 177 lb. per acre on estates and 69 lb. per acre on peasant holdings, in the same season. The breeding stocks are therefore being selected on their response to much more favourable conditions than those which the variety is required to meet in general cultivation, and it is in fact a rather weak point with V.135 that it is essentially a " good land cotton." Progeny row work must be carried on under conditions that will give the least environmental variation, and these are much more easily attained at high than at low fertility levels. It is possible, however, to carry out small bulk trials on poor land and it is proposed in future to test VH small bulks on a hillside of low fertility comparable with very large areas of St. Vincent cotton land.

Variety Trial.

The main Sea Island varieties were tried out against two promising VH hybrids. The varieties, whose important characteristics can be seen by reference to a similar trial conducted in 1939–40, were respectively :—St. Vincent Superfine (V.135), Barbados Sea Island (BSI), Nevis Sea Island (NSI), Montserrat Sea Island (MSI), BD, a St. Vincent " ordinary " selection, and Sea Island White (SIW) ; and the two VH hybrids VH.9 and VH.10.

The known heterogeneity of the soil of the experimental area was such that it was decided to lay out an 8×8 Latin Square. The individual plot size was $4' \times 40'$ with two plants per hole at $4' \times 2'$ spacing.

Significant differences between strains were recorded for all characters, but it is clear that for a satisfactory comparison of lint yields a more uniform area of land and larger plots are necessary. With a coefficient of variation of 29% only gross differences are significant.

Confirmation of the past season's results was obtained for all characters with, it is to be noted, the same significance of differences in most cases.

Flowering was assessed this season rather differently. The mean plot value was obtained by taking actual plant values of number of

TABLE III.

Strain.	Germination.	Days to Flower.	Boll Loculi Value.	Bolls per Plot.	Seed Cotton.	Lint.	Lint Index.	Seed Weight.	Ginning %	Seeds per Boll.
					Kgm.	Kgm.	mgm.	mgm.		
V.135 = V(39)8 ...	69·0	68·0	3·037	964	2·13	0·55	4·14	11·74	26·0	13·8
VH. 9 = VH(39)12	72·4	67·8	3·342	881	1·97	0·60	5·20	12·00	30·0	13·0
VH.10 = VH(39)17	70·5	68·9	3·365	726	1·65	0·50	5·10	11·80	30·1	13·6
BSI = Ba 1–14	81·4	66·7	3·220	1086	1·88	0·45	3·28	10·48	23·9	12·4
NSI = Ba 1–8B	79·5	66·2	3·100	729	1·76	0·48	4·21	10·96	27·6	16·1
MSI = Ba 1–5	85·5	69·1	3·266	627	1·64	0·55	6·50	12·44	33·5	13·9
BD = Ba 1–12	86·4	64·2	3·413	891	2·18	0·61	4·49	11·30	28·4	15·1
SIW = Ba 1–4	88·8	63·6	3·229	1114	2·52	0·83	5·36	10·90	33·0	13·7
General Mean	79·2	66·8	3·246	879	1·97	0·57	4·73	11·45	29·1	13·9
C.V.%	11·9	2·4	1·0	23·4	26·2	29·0	4·3	3·2	2·9	7·4
Significance of Differences ...	**	***	V.S.	***	*	**	VS.	VS.	VS.	***

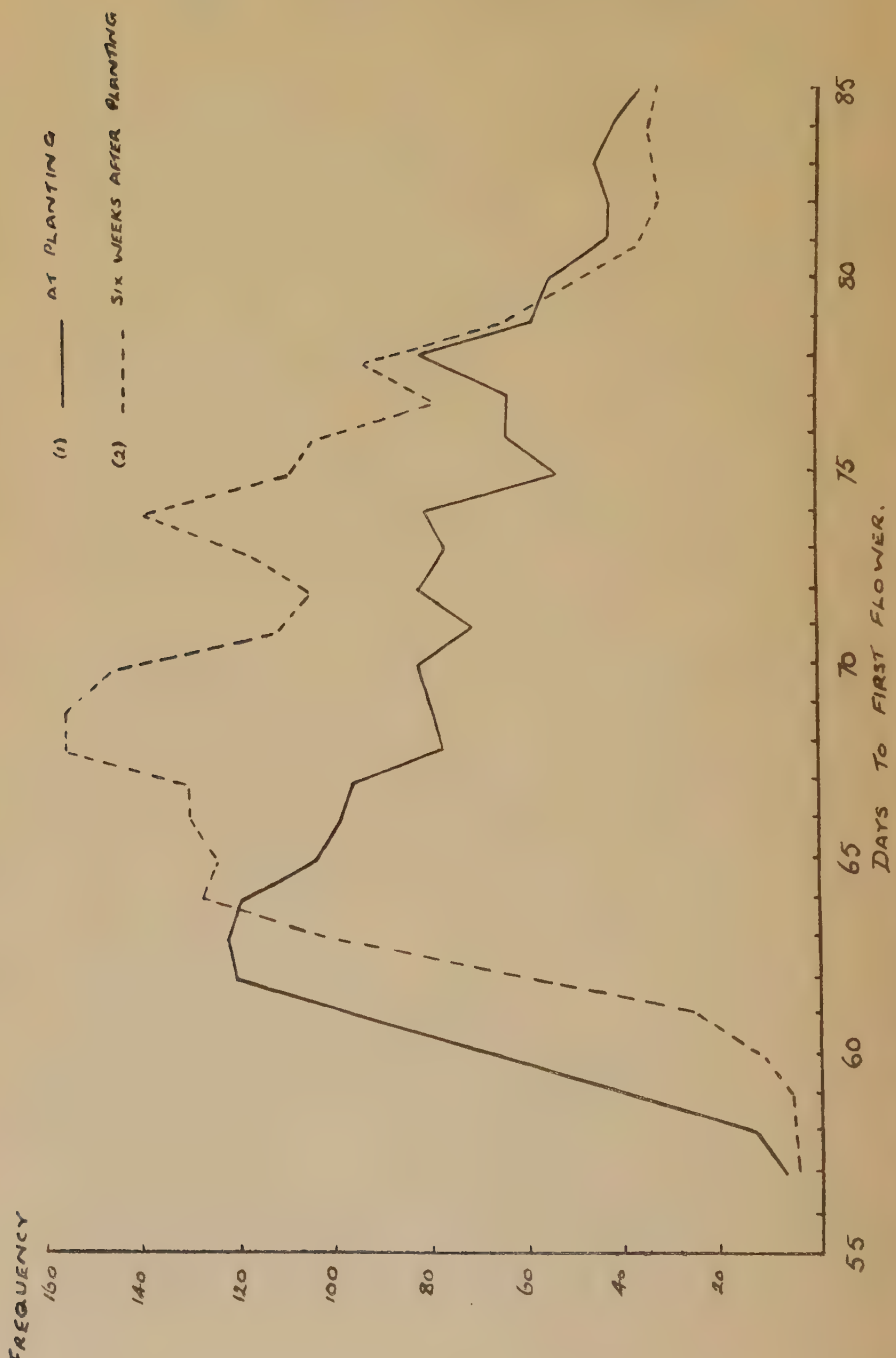
STRAIN ORDER AND SIGNIFICANCE OF DIFFERENCES.

Germination	SIW, BD, MSI, BSI, NSI, VH.9, VH.10, V.135
Days to Flower	SIW, BD, NSI, BSI, VH.9, V.135, VH.10, MSI
Boll Loculi Value	BD, VH.10, VH.9, MSI, SIW, BSI, NSI, V.135
Bolls per Plot	SIW, BSI, V.135, BD, VH.9, NSI, VH.10, MSI
Seed Cotton	SIW, BD, V.135, VH.9, BSI, NSI, VH.10, MSI
Lint	SIW, BD, VH.9, V.135, MSI, VH.10, NSI, BSI
Lint Index	MSI, SIW, VH.9, VH.10, BD, NSI, V.135, BSI
Seed Weight	MSI, VH.9, VH.10, V.135, BD, NSI, SIW, BSI
Ginning %	MSI, SIW, VH.10, VH.9, BD, NSI, V.135, BSI
Seeds per Boll	NSI, BD, MSI, V.135, SIW, VH.10, V.H.9 BSI

days to flower. As a result, the contention that NSI is a potentially early strain whose actual lateness is due to its inherent shedding trait is now proved. The node number values of the past seasons are therefore indicative of the potential earliness of the varieties.

Among the superfine Sea Island varieties the VH.9 hybrid has again been the highest yielder. SIW has proved beyond question the best yielding Sea Island variety in St. Vincent. Normally it is extremely

FIGURE 1.
MOVING AVERAGES OF DAYS TO FIRST FLOWER.
EFFECT OF TIME OF APPLICATION OF FERTILIZER.



vigorous, and in the season under review it was so prolific that it surpassed the superfine varieties even in bolling.

Since the behaviour of most of these varieties has now been under observation for three seasons and the required information has been obtained, it has been decided to replace some with new varieties. The Variety Trial of 1941–42 will consist of the following :—

V.135, Sea Island Fuzzy, Bleak Hall, Seabrook, VH.8, VH.9 and VH.10.

Manurial Experiment.

It was previously reported (1938–39) that a Manurial Experiment had shown a demonstrable increase in lint yield due to potash, on badly eroded hillside land. In addition, both lint per boll and bolling indicated that the nitrogen applications, which did not give a significant response, were inadequate. Some doubt existed, however, as to the greater relative importance of potash over nitrogen on the comparatively flat land of this Station. Also the precise combination requirements of nitrogenous and potassic fertilizers here had never been studied.

Consequently, a simple $2\times2\times2$ design was adopted to include two levels each of nitrogen and potash, and also early and late application of the fertilizers. Time of application was included in the hope of getting a lead on the problem of ensuring the greatest possible uniformity in the small plots used in the breeding work.

The excellent growth of most of the plants which received the fertilizer at time of planting suggested that this treatment would induce earliness. But, unfortunately, the planters in applying the fertilizer covered some of the seeds too deeply, and this was responsible for a high proportion of retarded plants in the treated plots. As a result, the adverse effect on the mean values was such that the difference could not be proved statistically so that, though the graph (*Fig.* 1) shows a trend towards earliness due to application at planting, in the summarised table below time effect has been eliminated and only fertilizer effects shown.

TABLE IV.

Summary of the Manurial Experiment.
Mean Plot Values with Time Effect Eliminated.
N_1 = 150 and N_2 = 300 lb. of Sulphate of Ammonia per Acre.
K_1 = 75 and K_2 = 150 lb. of Sulphate of Potash per Acre.

Analysis for :—	N_1K_1	N_2K_1	N_1K_2	N_2K_2	*C.V.* %	*Sig.*	*Effect.*
Plant Height (cms.) ...	121·4	142·2	132·0	148·9	5·0	***	Nitrogen
Bolling	31·5	33·6	31·2	35·7	9·5	**	Nitrogen
Total Lint (kgms.) ...	0·684	0·710	0·653	0·798	10·6	**	Nitrogen and NK
Lint Index (mgms.) ...	4·07	4·23	4·05	4·23	2·2	***	Nitrogen
Seeds per Boll	13·1	12·2	12·7	13·0	6·0	**	NK

Significant differences were detected for all recorded characters except days to first flower and seed cotton per boll.

The significant increments in yield due to the increased dosage of sulphate of ammonia show clearly that nitrogen is the greatest single factor affecting yield. The significantly favourable NK interactions, in the analyses of variance for total lint and seeds per boll, show that while potash alone did not result in any appreciable increase in yield the combination fertilizer is of some importance. This is more apparent on consideration of yield synthesis which can be interpreted as bolling × lint index × seeds per boll. It can be seen from Table IV that seeds per boll is affected most by the NK interaction.

Time of application, while giving no positive lead as regards the uniformity of the plant population, indicates that, with careful application, some reduction in total crop maturity period could be achieved. On the other hand, examination of the nitrogen-potash combinations suggests that with the double dosage of potash this latter fertilizer is not fully available when applied at time of planting, and the subsequent yield figures indicate that there is some leaching under the high rainfall conditions which prevail at this Station. Clearly then the early application of fertilizer must depend on the rainfall conditions which are likely to occur during the early stages of growth.

The experimental results suggest that the most economical fertilizer, under the circumstances, is N_2K_1 applied a few weeks after planting.

Miscellaneous Experiments.

Maintenance of Sea Island varieties in variable bulks was undertaken, and the improvement of strains in five plant plots was carried out as usual during the season.

A seed multiplication area in which the individual yield of 2,000 plants was recorded is expected to provide useful information on the relation between plot size and error variance in small-plot replicated experiments. Preliminary application of the quasi-factorial design to the data obtained indicates a greater efficiency than equivalent randomized blocks. The complete statistical treatment, which is extensive, will be the subject of a paper to be published elsewhere.

Acknowledgment.

The suggestions and criticisms of the Geneticist, Cotton Research Station, Trinidad, have proved invaluable and the writer wishes to record his grateful appreciation.

PROGRAMME OF WORK FOR THE 1940-41 SEASON.

1. *Superfine Main Breeding Trial.*—To maintain and improve the superfine V.135 seed supply and purify BSI breeding stocks. A doubled haploid of the original V.135 is to be included, to observe its variability, with six V.135 and three BSI strains, replicated ten times in eight plant plots.

2. *VH Breeding Trial.*—A thirty-one strain quasi-factorial design using three VH varieties. Seven strains of VH(40)1, eighteen of VH(40)5 and VH(40)11, and six of VH(40)16, belonging respectively to VH.8, 9 and 10. Eight plant plots.

3. *Small Bulks Trial.*—Comparison of five VH strains against V.135 on poor land.

4. *Variety Trial.*—Comparisons of the varieties Sea Island Fuzzy, Bleak Hall, Seabrook, VH.8, VH.9 and VH.10 against V.135 are to be made in a randomized block design with eight replications.

5. *Manurial Experiment.*—3×2×2 lay-out with three varieties and two levels each of nitrogen and compost. Partial confounding of Nitrogen×Compost and Variety×Nitrogen×Compost interactions. To investigate the physiological yield balance of two V.135 strains and one BSI.

6. *Type Collection.*—Maintenance of Sea Island Varieties.

(Included by courtesy of the Fiji Government.)

FIJI.

GENERAL EXPERIMENTAL STATION, SIGATOKA, COTTON PROGRESS REPORT FOR THE SEASON 1940-41.

BY

D. A. DONALD.

The cotton season under review was from 1st November, 1940 to 30th September, 1941. Sowing was done under rather dry conditions resulting in poor germination necessitating repeated sowings. Eventually a fair stand was obtained. In February a severe hurricane occurred which did extensive damage to cotton and other crops. Timely attention as regards pruning of branches and packing of soil to roots saved much of the crop, but recovery was slow and the resulting crop poor. A plot of Upland cotton strains under trial was the least affected by the hurricane on account of the plants being low and bushy, owing to heavy infestation by tip worm.

Unusually heavy rainfall in April and June did much damage to ripening cotton, and rendered picking difficult. Yields of district cotton were low and weather-stained.

The total rainfall for the period October to September, 1941 inclusive was 64·15 inches which is 7·31 inches below average. Rain fell on 174 days which is 23 days above average.

Agriculture.

Exhaustion Experiment.—This experiment was initiated in the season 1939/40 and continued during the current season. Sugar cane, maize and cotton are grown in duplicate plots. Average yields of seed cotton per acre were 240 lb. per acre in 1939/40 and 671 lb. in 1940/41.

Fertility Experiment.—This experiment was based on a similar experiment designed in Uganda in collaboration with Rothamsted but modified to meet local conditions and requirements. The objects are to determine the effect of :—(*a*) Rotation including a legume as a grain crop, (*b*) green manure, (*c*) weed fallow (12 months and 18 months), (*d*) farm yard manure, on fertility of the soil as measured by the maize crop in the rotation.

The crops in use are maize, rice, potatoes, cotton, cowpea (grain crop), cowpea and Mauritius bean (green manure crops) sweet potatoes.

The lay out of the experiment is in four rotations of a 3 years cycle replicated twice making in all 24 plots, which are further sub-divided into 48 sub plots, half of which receive a 5 ton per acre application of compost.

The experiment was commenced in 1939–40 season when all plots were planted. Significant comparison will not be attempted until the third course of each rotation has been completed.

Genetics and Breeding.

Bulk Cottons.—One acre of bulk selections of Sea Island cotton was severely damaged by the hurricane and yield was 50% of normal.

Re-selection Backcross 172/23/1 was issued to growers for multiplication. The crop suffered severely in the hurricane and even after recovery continued to shed its squares and young bolls. Fourteen acres were planted and yielded at the rate of 318 lb. seed cotton per acre.

Re-selection Backcross 172/23/5 was grown in the Exhaustion and Fertility trials at the Station. This crop recovered well from the effects of the hurricane. The lower and middle crops were, however, shed. A mean yield of 605 lb. seed cotton per acre was obtained.

Upland Cotton Variety Trial.—Thirteen strains of Upland cotton received from Australia were grown in observation rows. The usual data were recorded.

Among the highest yielders were " Half and Half " with 1,452 lb. seed cotton and " Delfos " with 1,270 lb. The lowest yield was from " DPL "—392 lb. per acre. Mean maximum lint length ranged from 24 mm. for " Half and Half " to 36 mm. for " Stoneville-2B ". Lint index from 5·76 for " Half and Half " to 7·72 for " Miller " and ginning outturn varied from 32·5% for " Okra Acala " to 39% for " Mexacala." The imported strains were susceptible to tip worm attack but suffered less from jassid. " Okra Acala" was glabrous, all other strains slightly hirsute. The yield obtained from Sea Island was 311 lb. per acre.

Progeny Rows.—Fifty progeny rows of Kidney Sea Island Third Backcross, Montserrat Sea Island, Sea Island and Kidney Sea Island Backcross were grown. The plot was severely damaged by the hurricane and drastic pruning had to be done to save the plants. Sixteen rows were selfed including all strains, of which eight show some promise.

Single Plant Selections.—Sixty single-plant selections were made from eleven progeny rows including all strains, of which twenty will be grown in progeny rows next season. Mean maximum lint length

of up to 57 mm. has been recorded on Kidney Sea Island Third Backcross. Lint is somewhat harsh in texture in most strains.

Pests and Diseases.

Cutworm.—Damage negligible.

Tipworm (*Earias fabia*).—Was again one of the major pests of cotton, particularly on the Upland strains.

Pink Bollworm (*Platyedra gossypiella*).—The incidence was slight.

Cotton Stainer (*Dysdercus insularis*).—Was again absent.

Harlequin Bug (*Tectacoris lineola*).—Was of minor importance.

Jassid (*Empoasca sp.*).—Appeared late in the season and attacked all strains of cotton.

Cotton Aphid.—Was observed on Sea Island cotton as early as December and multiplied rapidly. Effective control was obtained by spraying with tobacco leaf extract.

The Green Vegetable Bug (*Nezara viridula*).—Was found on cotton in small numbers early in the season. Hand-picking of the bugs was carried out periodically. The Government Entomologist released two colonies of a parasite (*Microphanurus basalis*) in April and May in an effort to control the pest.

Blackarm disease (*Bacterium malvacearum*).—The incidence of this disease was very slight.

PROGRAMME FOR 1941-42.

In view of the Government's decision to withdraw its support from the cotton industry, no commercial crop of cotton will be grown in Fiji during the season 1941/42. Work on the Station will be restricted to the maintenance and improvement of the existing strains against the time when Fiji may be in a position to revive the industry.

EMPIRE COTTON GROWING CORPORATION

9 Kingsmere Road, Wimbledon Common, London, S.W.19

List of Publications issued to date. Those still in print can be obtained direct from the Corporation at the above address. Those out of print are marked with an asterisk. The prices include postage.

GENERAL AND TERRITORIAL.

"Cotton Growing within the British Empire and The World's Capacity for Consuming Cotton Goods." J. W. McConnel. 1921. Price **2s.**

★ "Cotton Growing in Nigeria." Sir Hector Duff. 1921.

"The Extension of Cotton Cultivation in Tanganyika Territory." Major Hastings Horne. 1922. Price **2s.**

★ "Cotton Cultivation in Nyasaland." H. C. Sampson. 1922.

"Cotton Growing in South Africa." G. F. Keatinge. 1923. Price **2s.**

★ "Cotton Growing within the British Empire." L. G. Killby. 1924.

"A Cotton Research Station for the British Empire." Professor J. B. Farmer and Mr. L. G. Killby. 1925. Price **2s.**

"Report on the Cotton-Growing Industry in Uganda, Kenya, and the Mwanza District of Tanganyika." Col. C. N. French. 1925. Price **1s. 3d.**

"Memorandum by the Mechanical Transport Sub-Committee." Mr. G. H. Baillie, Mr. R. H. Brackenbury, Col. C. N. French. 1925. Price **2s.**

"Report on the Cotton-Growing Industry of Nigeria, 1926." Col. C. N. French. 1926. Price **2s.**

★ "The Principles and Practice of Yield Trials." F. L. Engledow and G. Udny Yule. 1926.

"Report on Suitable Rotation Crops for Cotton." H. C. Sampson. 1927. Price **1s.**

"Cotton Growing in Southern Africa and the Rhodesias." Report on a Tour undertaken by Sir James Currie, Mr. J. S. Addison, and Mr. H. C. Jefferys. 1927. Price **2s.**

★ "Reports from Turkestan Plant Breeding Station, Tashkent." 1928.

"Review of the Situation in the Principal Cotton-Growing Territories of the Empire, and a Summary of the Main Activities of the Corporation since their Formation." 1928. Price **9d.**

★ Out of print.

* **No. 5.** Further Studies on Transport in the Cotton Plant. I. Preliminary Observations on the Transport of Phosphorus, Potassium and Calcium. II. An Ontogenetic Study of Concentrations and Vertical Gradients. T. G. Mason and E. J. Maskell. 1934.

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* Out of print.

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